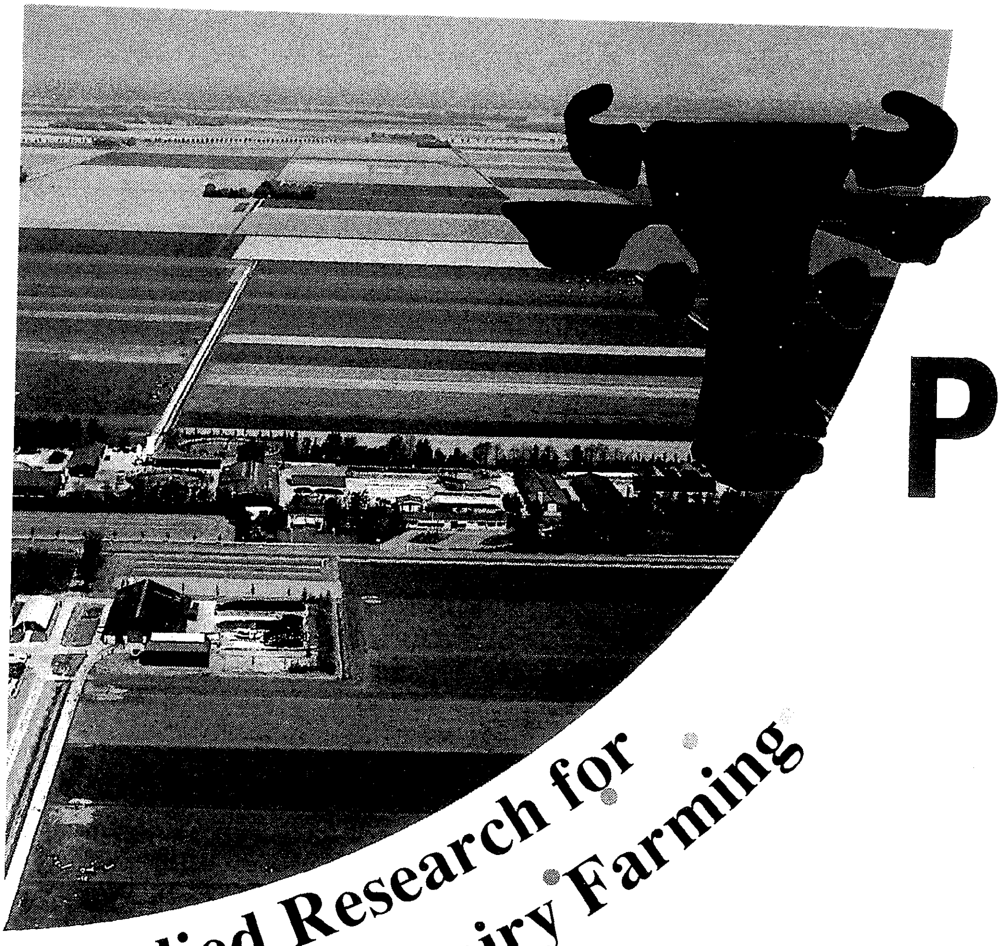

PR

Applied Research for Sustainable Dairy Farming

Proceedings of the Symposium

Research Station for Cattle, Sheep and Horse Husbandry

May 31 - June 2, 1995

Colophon

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Editors

W. Luten
H. Snoek
S. Schukking
M. Verboon

June 1995

Preface

In 1970 the Research Station for Cattle, Sheep and Horse Husbandry (PR) was founded and later located in Lelystad. The experimental farm the Waiboerhoeve was built 10 years earlier in Millingen aan de Rijn in the East of the Netherlands. In 1971 the Waiboerhoeve was rebuild in Lelystad as the experimental farm of the PR. This year we celebrate the 25th anniversaty of the Research Station and the 35th anniversaty of the Waiboerhoeve. In this context the symposium for sustainable agriculture is organized. This initiative is meant to discuss sustainability in dairy husbandty with farmers and researchers of Europe. This is an important issue in Western Europe.

PR and Waiboerhoeve are one organization together with the five regional experimental farms for applied research. Financial deficits are paid on a 50/50 basis by the Ministry of Agriculture, and the farmers organizations (Landbouwschap). The contribution by the farmers quarantees that the experiments have a practical use. This symposium presents results of applied research. The symposium was organized by a committee of PR employees:

Ir. Willem Luten
Ing. Herman Snoek
Ir. Sije Schukking
Ir. Rinus Verboon

We hope that the proceedings of this symposium are helpfull in stimulating Sustainable Dairy Farming.

A. Kuipers,
director.

Contents

View of dairy farmers

Conclusions

Applied research in the Netherlands

A. Kuipers (director PR)

Applied research is performed in an organizational assembly of 5 regional experimental farms and the central farm unit, the Waiboerhoeve. The locations of the experimental farms are illustrated in Figure 1. The regional farms are dairy farms. The Waiboerhoeve exists of 4 dairy, 1 beef, 1 calf fattening, 1 sheep and 1 horse farm.

Applied research means that the results of the experiments can directly be applied by the farmer and his farming business. In the past, several important developments were initiated at the experimental farms whilst other tools were shown to fail in their practica1 use.
Examples are the development and introduction of the loose housing system (stall housing) for Dutch circumstances; the negative experiences with the harvestores for silage storage resulting in the rejection of these silos for practica1 use; the introduction of the cold barn houses for calves; the use of silage covered by plastics; the idea of injecting slurry into the soil; the high costs of zero-grazing resulting in advice not to use it; the

Figure 1 Location of experimental farms

guidelines for nitrogen application on grasslands. Now the research programme is mainly concentrated on environmental issues, management practices at farm level and milktechnique. The current research programmes of PR are listed in Table 1. For the last 5 years environmental research has been the top-ranking topic. This is owing to public pressure which urges the farming community to develop less polluting operating systems. Especially the loss of nutrients to the groundwater and the loss of ammonia to the air are being tackled. The PR believes that most of the environmental problems can be solved in the field by adjusting the fet-tilizer-recommendations, by introducing new manure handling techniques and by lowering the intensity of cattle grazing. Higher production levels per cow may lower the grazing intensity. In addition, methods are being developed that require adaptation of cattle housing and manure storage facilities. However, the high costs of these adaptations demands a search for more simple solutions.
Four years ago a new farm was established to study the nutrient cycle within the farm operation. This farm, called De Marke, has now been in operation for three years and the improvements in reducing nutrient losses can be illustrated. Also a farm set-up has been studied at the Waiboerhoeve, in which grass farming was compared to grass-clover farming. On the experimental farm Cranendonck, in the Southern part of the country, experience is being acquired with fodder crops, including lucerne, on dry sandy soils. The purpose is to limit the amount of water used for sprinkling the crops in the summer-time. In some parts of the country the groundwater level is becoming lower. This is considered unfavourable for the general water supply in the nature areas.

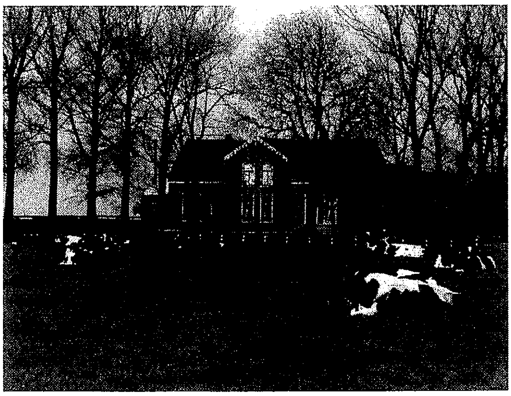
Management research is performed on an individual cow base and at farm-level. A high producing herd with an average milk production of nearly 10.000 kg is being studied at the Waiboerhoeve. Health-data are collected and analyzed on all research farms.

Table 1 Research programme of the PR Research location

Programme	Research location
Environmental research:	
■ Farm system for nutrient management	De Marke
■ Farm system on dry sandy soils	Cranendonck
■ Farm system with grass and clover	Waiboerhoeve
■ Reducing nutrient losses by fertilization and grassland use	all
■ Reducing nutrient losses by feeding	all
■ Reducing ammonia losses by handling manure	all
■ Reducing use of herbicides	all
Management research:	
■ Farm system for high milk production	Waiboerhoeve
■ Cow-management	all
■ Dairy-farm models	all
Milk and machine milking research:	
■ Farm system with robotic milking	Waiboerhoeve
■ Improving milking techniques	all
■ Improving milk quality	all
Others:	
■ Farm system with integration of nature aspects	Zegveld
■ Beef cattle	Waiboerhoeve
■ Sheep	Waiboerhoeve
■ Horses	Waiboerhoeve
■ International co-operation	

Over the years the PR-dairy-farm-model has been developed with which effects of changes in management strategies on the technical and economic results of the farm can be calculated. Recently a nutrient module has been added to this farm model. This model is a major support to research. Alternative management plans are simulated in a normative way. The programme is also used by the advisory service to provide insight into changes in different management strategies.

The milking trials are focussed on developing better milking techniques, improving the quality of milk and reducing the amount of waste water. Experience is going on with two types of milking robots installed at the Waiboerhoeve. The PR believes that automatic milking will be part of the near future on many dairy farms in this country.



A topic of growing interest is the integration of nature on dairy farms. Trials and demonstrations regarding meadow birds and flora on the border of the paddocks and the edges of ditches are carried out at the experimental farm Zegveld in the Western part of the country, where low lying peat soil grassland, is common.

Also organic farming becomes a part of the programme, starting with an analysing and advisoty system and collecting data in practice for management support.

This symposium will present results from the projects mentioned, from projects of some scientific institutes in our country and also from research on sustainable dairy farming carried out in other European countries and the meaning and experience of farmers from 5 countries.

Sustainable dairy farming in the Netherlands

P. Miedema (Dutch Board of Agriculture)

It is my honour to welcome you to this symposium on applied research for sustainable dairy farming, on behalf of the Research Station for Cattle, Sheep and Horse Husbandry. It is a pleasure indeed to celebrate a long histot-y of applied research on behalf of Dutch dairy farming; research that has contributed considerably to the position of Dutch daity farming today. On behalf of fellow-farmers I would like to congratulate the institute on reaching a respectable age and most of all on its achievements throughout the years.

Twenty-five and hopefully many more years of research to come. One could ask oneself whether there are any more questions left to be answered. Well indeed there are. From a scientific point of view, every answer will provoke new questions. From a farmers point of view, there will always be the need for improved production and production methods. Furthermore, there will always be a need to adapt to new circumstances in a world that changes continuously.

This symposium will consider sustainable dairy farming. To dairy farmers, there are two aspects to sustainability. On the one hand farming has to be profitable in order to maintain a viable long term income for farmers. On the other hand, dairy farming as any other human activity, must minimize its negative impact on the environment and maximize the efficiency of natural resource use. These are two major challenges which dairy farming must deal with. Possibly even more challenging is the necessity to cope with both aspects at the same time and to find solutions for the conflicts between the two.

Dairy farming is going through significant changes. At present there is a change in attitude towards agriculture. No longer is the need for sufficient food supply the driving force that pushes new developments. In a situation in which food is abundant and relatively cheap, concern about the negative environmental effects of daity farming, as well as ethical issues such as animal welfare, will become more important as a waymark towards the future. At present farmers are also being assigned a role in preserving landscape and biodiversity. Not only will this change in attitude be translated into more rigorous regulations. Daity farmers should anticipate a market benefit for related characteristics.

With respect to the environmental aspects of sustainability, Dutch dairy farmers are working hard in many ways to take their responsibility in reducing the negative environmental effects of their acitivities.

Within a few years a huge number of farmers has started to improve nutrient management by keeping accounts of inputs and outputs of nutrients on their farms and by cutting unnecessary losses. Keeping these accounts not only proves to be an effective management tool, but it should be the central tool in regulation of the use of nutrients.

A check-list has been developed that can help farmers manage the more efficient use of several other environment-related inputs and natural resources such as water, energy, pesticides and disinfectants. In 1995 this checklist will be introduced on a large number of farms, and these farms will be supported by the advisoty service in planning a strategy towards a reduction of inputs while maintaining the production level.
Another example of farmers action is that the plastics that have been used for conset-ving silage are collected for recycling. In several parts of the country this has been taking place for a couple of years already and preparations are being made to make this possible in the whole of the Netherlands.

Thus I have given a few examples which show that farmers are aware of their responsibility towards pet-forming sustainable agriculture. The authorities would like to stimulate farmers to hurty towards sustainablity, by imposing strict

Tabel 1. Dutch dairy farming towards sustainability: some relative achievements throughout the years (source: LEI-DLO)

Year	1986	1988	1989	1990	1991	1992
Nitrogen surplus (per hectare)	100	90		82		80
Phosphorus surplus (per hectare)			100			90
Emission of ammonia (Netherlands)				100		75
Herbicides (Netherlands)					100	93

regulations. It should however be considered of great value that farmers do initiate positive action themselves. This should be acknowledged and supported by allowing farmers time to adapt. Fut-thermore, since every farm has its own characteristics and therefore its own specific route towards sustainability, regulations should allow for an individual approach. Such an approach will make farmers more eager to demonstrate their responsiblity since good farming practice will be rewarded as much as possible.

Although the politica1 discussion is not yet at an end, it is clear that a lot remains to be achieved in order to improve efficiency of nutrient inputs. This means that there is need for further development of tools for nutrient management. It also means further improvement of grassland potential, reduction of losses during roughage conservation processes and the further fine-tuning of feeding strategies. There are plenty of tasks here for applied research.

Fundamental research should also be petformed in order to establish relationships between agricultural activities and negative environmental effects. Regulations should be based on solid research. The most fustrating example of Dutch farmers feeling there to be a lack of solid research, is the regulations on ammonia. In the Netherlands, restrictions to farm size are imposed on farmers that happen to have woodlands in the vicinity of their farm. Since the relationship between emission by individual farms and deposition to the surroundings is uncet-tain, it is understandable that individual farmers protest against these rules.

As mentioned before there is another aspect to sustainability, that is to provide farmers and their families with a viable long term income. Although dairy farming incomes have been satisfactory throughout the previous years, recent developments will push incomes down rather then push them up. International developments, such as the liberation of world trade and renewed contact with Eastern Europe will allow more competition on the European market. It is important to use the opportunities offered by these developments and to minimize negative effects. Probably more important, but too far away to discuss in depth now, will be the choices made in the follow-up to the European Union Dairy Policy in the next decade.

In order to handle more competition, farmers will on the one hand have to continue cutting production costs, while on the other hand working towards higher quality standards. In a situation in which it is either impossible or expensive for individual farmers to increase farm size, improvement of the efficiency of production has become even more relevant in order to maintain income. The income-related aspect of sustainability should be as much an item of research as the environment-related aspect. In many ways, taking care of the environment will run alongside cutting costs. However both aims are also conflicting in many ways. Applied research should not only develop tools and methods that can help farmers work their way towards sustainability. It should also have a role in defining tensions between both aspects of sustainability, in order to support decision-makers in making the right decisions.

It is my hope that this symposium will contribute towards fulfilling the task of applied research and that this meeting will be fruitful to all those participating. In many ways dairy farmers from different regions in Europe have similar problems to tackle. I therefore hope that meetings like this may contribute to international cooperation between research workers.

Grassland nitrogen fertilization from economical and environmental point of view

Th.V.Vellinga (PR-Lelystad)

Abstract

To realize the environmental standards for sut-face and ground water the N inputs on daity farms have to be reduced. A decrease in the N inputs will cause a decrease in farmers income and increase the scarcity of land. Optimization of N recommendations must meet environmental goals with a minimum of yield decrease. The recently implemented fertilizer recommendations must be further improved. This can be done by a good estimate of the Nitrogen Supply of the soil during the growing season, a good estimate of residual effects of preceding applications, N application strongly related to the planned yield and omitting the fertilization of urine spots. Cooperation between fundamental and applied research is going on for optimal exploitation of knowledge.

1. Introduction

Dairy husbandry in the Netherlands is intensive. The average milk quota per ha was 12,500 kg (in 1988), with regional variations between about 8000 and 20,000 kg. The milk quotas per ha are especially high on sandy soils.

Therefore, on a lot of dairy farms the N fertilization is very high, at the economic optimum or even higher. Recommendations for the economic optimum are based on a marginal effect of 7.5 kg dry matter per kg of N.

These high N applications, together with intensive grazing cause unacceptable losses to surface and ground water. On sandy soils nitrate leaching causes N concentrations in the ground water, which are higher than the EC standard for drinking water of 50 mg l-1 On clay and peat soils surface runoff is responsible for higher N concentrations in surface water than the Dutch standard of 2.2 mg l-1.

Reduction of N losses to the environment is important. This can be simply realized by a strong reduction of the N input on dairy farms. This will lead to a fall in farmers income, as well as more land is being needed to produce all the roughage. But land is scarce and will become even scarcer in the future. Therefore, dairy farming will remain as intensive as possible.

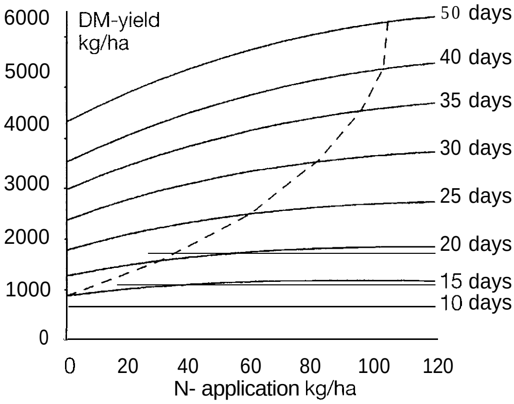
The first step to reduce the losses to the environment is to improve the accuracy of fertilizer N recommendations, in order to meet the needs of the crop more accurately and to reduce the risk of losses as much as possible. Improvement of N fet-tilization is not only environmentally profitable, but also economical. This improvement has been realized in 1994.

Environmentally and economically sound recommendations partly have the same objective (in the range of 300 - 400 kg N per ha per year), but can clash when the fertilization must be reduced severely to about 150 kg N per ha per year. In this case, the only way to produce as much roughage as possible is to optimize N fertilization and grassland utilization. Therefore, in research special attention has been paid to the influence of grazing, especially the uneven distribution of returned nutrients from dung and urine. Other aspects were the influence of weather conditions on mineralization and growth. These aspects are not completely new, but to achieve good fertilizer

Table 1 Groups of Apparent Nitrogen Supply, their average supply and recovery, the importance of the groups and the average optimal N-application from manure and industrial fertilizers.

Group	Soil	ANS	ANR	% of grassland	optimal N.
1	peat soils, ditch water level 60 cm	300	0.6	6	200
2	peat soil, ditch water level 30 cm	230	0.6	13	300
3	peaty soils, sandy soils with high org matter	200	0.8	10	340
4	clay soils, other sandy soils	140	0.8	71	400

Figure 1 The DM-yield at different growing periods with increasing N-appications. The dashed line shows where the marginal effect of 7.5 kg DM per kg N is realized



recommendations, extensive experiments have been necessary.

2. Improvement of the N fertilization in 1994

Before 1994, the same fertilizer N recommendations were used on all soil types, except well drained peat soils. The latter had a very high Nitrogen Supply by mineralization of the peat. Research in 1992 showed that optimal N application depended strongly on Nitrogen Supply (NS) of the soil and on weather conditions. This idea has been elaborated on and has resulted in new recommendations, based on four different soil groups (Table 1), which differ in nitrogen supply (NS) and nitrogen recovery per year (NR). The recommendations per cut, which strongly regulate the amount of N applied per year, have been evaluated and improved. Basis of the recommendations per cut is the relationship between the dry matter yield, N application and growing time (Figure 1). The second cut is chosen as an example, the solid lines are the dm yields at different growing periods. The dashed line crosses the dm lines at the point where the marginal N response equals 7.5 kg dm per kg N and indicates the optimal N application at different dm yields and growing periods. It can be seen that the optimal N application increases with increasing number of growing days and with increasing yield. This increment of the optimal N application is stronger at lower yield levels. For practica1 use three yield groups were distinguished: lower than 1500 kg dm, 1500 - 2500 kg dm per ha and more than 2500 kg dm per ha. A correction was incorporated for the next cut when the planned yield and N uptake were lower.

Grazing.

An analysis of the results of parallel grazing and

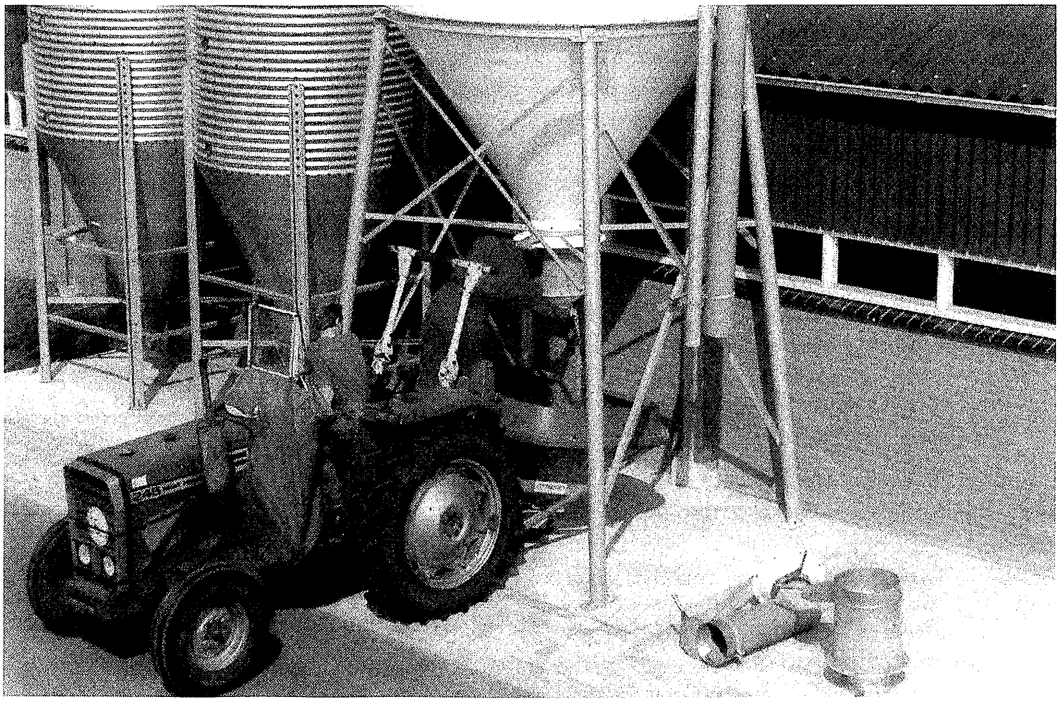


Table 2 Factors related to grazing which influence the optimal N application per year.

Factor	Optimal N-application	reduction
Only cutting	451	0
Return of nutrients	412	-40
Urine scorch (long term effects)	349	-100
Poaching	396	-55

cutting experiments has shown that N fettilization recommendations under grazing conditions must be lower than under cutting conditions. However, the variation between sites and between years on the same site was too large to simply reduce the recommendations for cut grassland by a given amount in order to arrive at a recommendation for grazing. Calculations showed that return of nutrints, poaching and urine scorching play an important role in this matter (Table 2). The latter two aspects are strongly related to sward quality. For adjustment of the recommendations, the condition of the grass sward should be taken into account, to allow for damage caused by grazing. Until now no practica1 tools are available, so this is not implemented.

Shortcomings of the recommendations.

The recommendations per cut are strongly related to yield and adaptations to growing conditions automatically occur: growth reduction results in less cuts or lower planned yields per cut and so in less N applied. But still these recommendations are based on average conditions and do not take into account the variation in nitrogen supply during the growing season. Moreover, the automatic corrections might not be sufficient to allow for changing growing conditions. Accumulation of mineral nitrogen in the soils might not be prevented.

It is also unsatisfactory that fertilizer recommendations for grazing have not been introduced owing to practica1 problems. About 80 % of the nutrients are returned by the grazing animal and it must be possible for them to be used it at least partially.

3. **Further optimization of N recommendations.**

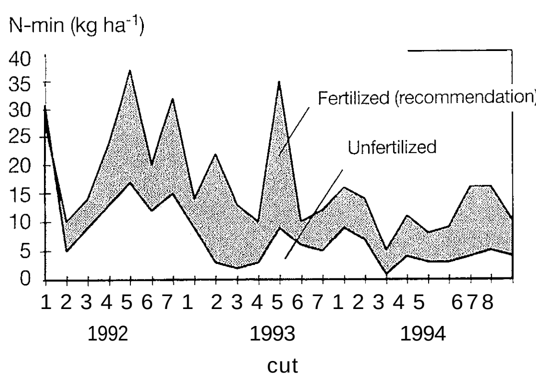
The need for extra research for a further improvement of the fertilizer recommendations was seen by government and farmers organisations. Extra funding stimulated new research projects. Institutes on fundamental and applied research were involved: the Research Station for cattle Husbandry , the Nutrient Management Institute, The Winand Staring Centre and the Institute for Agrobiology and Soil Fertility. Coordination was done by a special team.

On the Research Station for Cattle Husbandry experiments were stat-ted to develop a System of Adjusted N Supply. This was based on the possibilities of correcting the nitrogen application per cut for accumulation of mineral nitrogen and a continuous variation of the planned yield. In this fertilization experiment, special attention was paid to measurement of the actual mineralization and the N_2O-emission. On peat soil the denitrification was measured, as we expected this to be the major cause of the lower N recovery on this soil type. Extra cutting experimenst were done to measure the residual effects of N from preceding applications during the complete growing season.

A grazing experiment to follow the N-fluxes under urine spots at different moments during the growing season. In this experiment special techniques are developed to deal with heterogenity. In a second grazing experiment the possibilities to reduce leaching by shortening the grazing season are investigated. Special attention is paid to aspects of grassland management (especially more silage in the autumn). On one of the experiental farms monitoring is done of leaching from grazed grassland and from crop rotations of grass and fodder crops on moist and dry sandy soils.

A special demand of the funding organisations

Figure 2 The amount of mineral nitrogen in the soil layer 0-30 cm during the growing season before every cut. N application according to the recommended scheme and on unfertilized plots on clay soil from 1992 to 1994



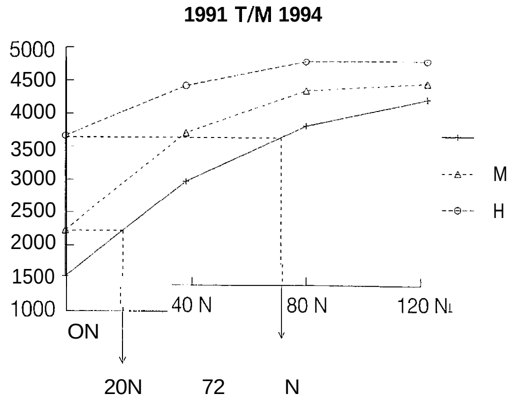
was an integration project, where all the results of the experiments and monitoring will be combined in one quantitative description of the N-fluxes in grassland. The goal of this description is to produce an improved system for N fertilizer recommendations. It is also an important tool to create good access to and use of all the experimental results.

4. **Results**

1 Under cutting conditions and with use of the current N fet-tilization recommendations, accumulation of mineral N hardly occurs, although mineral N is at a higher level on fertilized plots (Figure 2). Therefore correction of N application for mineral N in the soil is of limited value. The average accumulation of mineral N is about 10 to 20 % higher under grazing conditions than under cutting conditions, but this accumulation is mainly concentrated in the urine spots.

2 Although hardly any accumulation of mineral N occurs, the residual effects of applied N in preceding cuts can be large, especially at the beginning of the growing season. Figure 3 shows the dm yield after 35 days in the second/third cut with one preceding cut receiving 0 and 40 kg N (Low and Medium) and two preceding cuts at the H(igh) pretreatment, receiving 80 kg N per ha per cut. The residual effect of the N in the preceding cuts is calculated as the compensatory amount of N that is needed in the second/third cut in order to realize the same yield. Residual effects between the Low and High pretreatment are in this experiment 72 kg N. Experiments on residual effects have been published before, but only during the end of the growing season and without unfertilized plots. Measurements indicate that part of the residual N is stored in the stubble, but other sources of easy available N are difficult to measure. So the relationship between the calculated remaining N in the soil plant system and the residual effects will be used to provide more accurate N recommendations.

Figure 3 The residual effects of preceding N from the first cut on the dm yield of the second/third cut after 35 days of growth.



3 The data of three years of experiments show a clear relationship between the optimum N application and the actual mineralization (Table 3). In 1992 the Nitrogen Supply on sand and clay was estimated at 140 kg N per ha per year. A high mineralization level in 1992 (183 and 245 kg N) resulted in a lower optimum N application, whereas in 1993 and 1994 a low mineralization level resulted in higher optimal N applications. This experiment shows that the use of accurate estimates of N mineralization is useful in optimizing N inputs also at lower levels of fertilization. Hassink (1995) developed a method based on the relationship between soil texture, equilibrium content of organic matter and the Nitrogen Supply of a grassland soil. This method is now being improved by incorporating soil temperature and moisture content.

4 Under grazing conditions tackling of the large

Tabel 3 Estimated and actual Nitrogen Supply, the fertilizer recommendations and the optimal N application (1 kg N = 7.5 kg dm) on sand and clay.

Soiltype	Year	Estimated ANS	Actual ANS	Recommendations	Optimal N
Clay	1992	140	245	400	< 308
	1993	200	94	397	515
	1994	200	44	386	568
Sand	1992	140	183	423	< 356
	1993	200	115	405	563
	1994	200	70	400	551

heterogeneity has been started. Techniques for selective N application by omitting urine spots have been developed. Work has started on constructing a machine for practical use. Stopping grazing earlier in the growing season will significantly reduce the accumulation of mineral nitrogen in the soil and the consecutive leaching. However, the practica1 problems of (light) silage cuts late in the growing season show that stopping the grazing season at an earlier time also has its disadvantages.

5. Conclusion

Although reduction of N inputs cannot be avoided when meeting environmental goals, the optimization of fertilization can significantly compensate for the decrease in yield. The most important aspects of fertilizer recommendations are: a good estimate of mineralization and residual effects of preceding N applications, a strong relationship between yield and N application and tackling the heterogenity by omitting fertilization of urine spots.
The cooperation between strategic/fundamental research and applied research by combining a knowledge of processes with their practica1 implications has great advantages.

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New application techniques make slurry again a valuable nutrient

A. P. Wouters (PR-Lelystad)

Abstract

Government policy to reduce the pollution of ground and sutface water with nitrogen and phosphate and air with ammonia from slurry, has resulted in restrictions concerning the amount of slurry and time of application on grassland and arable land, and in several new application techniques for use on grassland and arable land. Injection techniques like tine, shallow injection with open and closed slits are very effective in reducing ammonia volatilization. However, injection techniques cause too much sward damage on grassland with a poor bearing capacity. Band spreading of slurry by trailing feet or dilution of slurry with water and application with a spray beam proved to be more suitable. In this way, slurry can also be applied early in spring without affecting bird life.

The utilization of nitrogen from slurry has improved considerably due to the change in application time and the use of new application techniques. On average, the utilization of slurry nitrogen almost doubles when using low emission techniques compared to sutface spreading. This contributes considerably to the reduction of nitrogen losses on dairy farms. On arable land, low emission methods of slurry application will also reduce nitrogen losses significantly.

1. Introduction

Since the sixties, dairy farming in The Netherlands has become very intensive. The system of separate collection of dung and urine has been replaced by the slurry system on most dairy farms. Advantages are an easier handling of manure and less need for bedding material. Till the mid eighties, farmers applied slurry mainly during winter and early spring to avoid the high costs of slurry storage and to minimize possible negative effects of surface spreading on grass growth and herbage intake during summer. The introduction of forage maize with its tolerance of high amounts of slurry encouraged the application of large quantities slurry on maize land.

In this paper the present methods of slurry application for grassland and arable land will be discussed in relation to environmental effects, nutrient utilization and nature conservation.

2. Environmental effects of slurty handling and government regulations

2.1. *Environmental effects*

Slurry handling till the mid eighties had a number of environmental drawbacks. Excessive amounts of slurry applied to, especially, sandy soils led to an accumulation of phosphates on these soils, reducing their phosphate fixing capacity (phosphate saturation) and increasing the risk of phosphate leaching.

Slurry application during winter contributed to leaching of nitrogen to groundwater as well as to run-off of nutrients to sutface water.

Around 1980, the contribution of ammonia volatilization from slurty to the acidification of the environment was recognized as being very serious. Before any measures were taken, the contribution of ammonia to the total emission of acidifying substances in The Netherlands was estimated at about 20% of which 63% was derived from cattle. On average, about 50% of the ammonia volatilization from cattle slurry was derived from slurry application, 20% from grazing and 30% from buildings and slurry storages.

2.2. *Regulations*

Government targets set for the phosphorus content in drinking and surface water are respectively: 2 and 0.15 mg total P per liter. Restrictions have been imposed on manure quantities to be applied, with phosphorus as a reference. At present, maximum manure applications of 65 kg P/ha on grassland and 48 kg P/ha on maize land are permitted. By 2000, P application should equal crop uptake. However, a recent desk study showed that to maintain the P-status of the soil at a sufficient level from an agricultural point of view, 13-20 kg P/ha has to be applied above crop uptake.

Nitrate content in groundwater, at a depth of 2 m below groundwater level, should not exceed 50 mg/l according to EU standards while according to the government's goal, surface water should contain less than 2.2 mg N/l in 2000. In order to prevent leaching and run-off, manure application is not allowed on grassland and on arable land (sandy soils only) from September till Februaty. Government policy aims at a reduction of the ammonia emission by 70% in the period 2000-2005 and by 80-90% in the period 2010-2015 relative to 1980's level. Therefore, use of low emission techniques have become obligatory.

3. New **slurty application techniques for grassland and maize land**

3.1 *Ammonia volatilization from slurty*

Ammonia volatilization occurs after urea, contained in the urine, has hydrolysed into CO2 and NH3 and this NH3 comes in contact with air. The volatilization of ammonia after surface spreading of slurry shows a large variation (Table 1). This variation is caused by slurry composition (concentration of ammonia, pH and dry matter content), environmental factors (weather conditions, soil type, soil condition and plant cover) and farm management factors (amount of slurry applied and application method).
Changing the composition of slurty and/or reducing the above ground surface area of slurry results in a lower ammonia volatilization. Based on these principles, several low emission techniques for slurry application have been developed.

3.2 *Utilization of nutrients from slurty on grassland*

In a sound fertilization scheme, artificial fertilizer should supplement nutrients applied by manure. The use of new application techniques result in a larger amount of available N, while the placing of slurt-y affects especially time of N availability and P utilization. The utilization of, for example N, from slurty can be expressed in terms of N-recovery which shows the part of the total amount of N from slurry taken up by the crop and in terms of efficiency index, which indicates how much fet-tilizer nitrogen has an equal effect on N uptake by the plant as 100 kg N from slurry.

3.3 *Application techniques for grassland and their effectiveness*

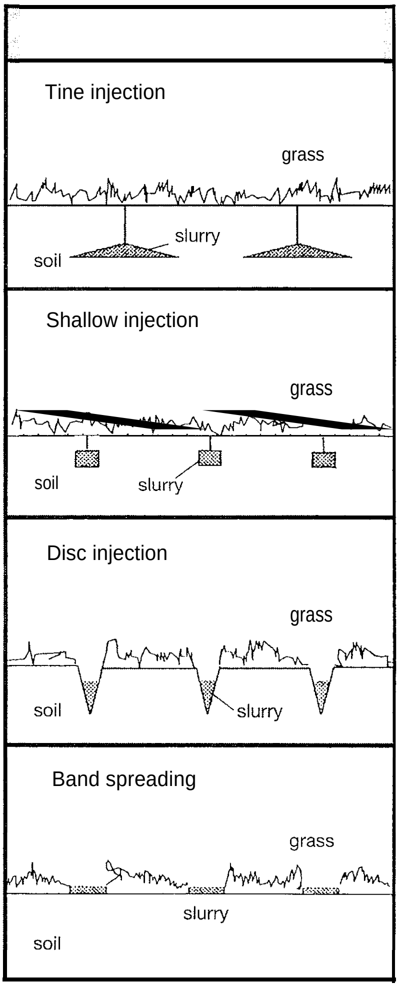
Tine or deep injection

Tine or deep injection of slurry, developed to prevent bad odours, has proved to be very effective in reducing ammonia volatilization (Table 1). With this technique, slurty is injected into grassland at a depth of about 15 cm below the soil sut-face with tines provided with a duck foot sweep at the base (Figure 1).
For a good result however, tine injection requires certain conditions: soils should have a sufficient bearing capacity, be not too dry at time of injection and tehreafter and be free of obstacles. Otherwise, wheelslip, dessication and/or scorching of grass along injection slits could cause sward damage.
In general, utilization of N from deep-injected slurry increased by 100% compared to sutface spreading (Table 2). With tine injection in summer

Table 1 Reduction of ammonia emission (compared to surface spreading and expressed as %) after slurry application with different techniques

Methods and techniques	Reduction (%)
Grassland	
Tine and shallow injection	> 95
Shallow injection with open slits	> 80
Band spreading by trailing feet	50-80
Dilution with water (1:3)	20-80
Irrigation during and after surface spreading	25-75
Acidification with nitric acid	
pH < 5	70-95
pH 5-6	30-80
Arable (maize) land	
Tine injection	> 95
Shallow injection with open slits/band spreading by trailing feet (slurry incorporated into top soil)	> 80
Incorporating slurry into soil immediately at time of application	70-95
Incorporating slurry following sutface spreading	35-95
Band spreading by trailing feet (slurry deposited at soil sutface)	35-70

Figure 1 Distrubution of slurry applied by different low emission techniques in the soil



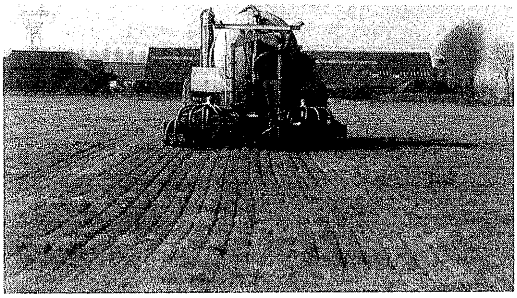
(after the second cut of the growing season) N utilization was in general lower than in spring.
On average, the nitrogen effect of injected slurry was more predictable over the years than after sut-face spreading. However, nitrogen from deep-injected slurry acted more slowly than from sutface-spread slurry.
The type of slurty (pig or cattle slurry) had no influence on the utilization of slurty N, except when the amount of mineral N was higher and hence more mineral N was available for plant uptake.
Results of experiments with deep-injected slurty on grassland on sandy soils showed that after yearly injection with cattle slurty for a period of five years, the phoshate status of the topsoil decreased significantly. The injected grassland reacted positively to an additional application of superphosphate despite the P supplied by injected slurry.
The utilization from potassium of deep-injected slurry appeared to be as good as potassium from fertilizer. In general, when large amounts of slurty are applied during the growing season in combination with a fairly high N application, potassium content of herbage will increase significantly. High potassium contents of herbage are undesirable because of possible animal health risks (grass tetany).

Shallow injection

The experiences with tine. injection led to the development of shallow injection with open and closed slits (Figure 1). Shallow injection with open slits implies that slurry is applied in slits at a distance of 0.2 to 0.3 m and at a depth of 5-8 cm

Table 2 Utilization of N from cattle slurry in terms of N-recovery (expressed as %) and efficiency index (based on N-uptake *100 of N from slurry in comparison to N-uptake of CAN-27 fertilizer) applied to sandy soils in early spring

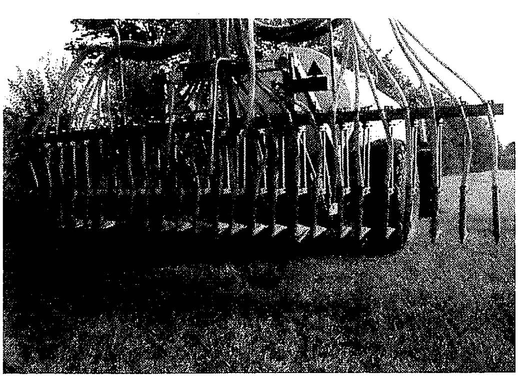
Method	No of years investigated	N-recovery	Efficiency index
Surface spreading	5	23	24
Tine injection	5	55	58
Sutface spreading	5	21	26
Tine injection	5	49	60
Surface spreading	3	26	24
Tine injection	3	62	76
Shallow injection with open slits	2	42	59
Shallow injection	2	50	70
Surface spreading	2	20	22
Tine injection	2	47	54
Shallow injection with open slits	2	50	56
Dilution with water (3% dry matte	2	35	39
Surface spreading	3	34	42
Dilution with water (1:2)	3	48	58



while the slits remain open. With shallow injection with closed slits, slurty is injected at a depth of 8-10 cm in slits made by tines without duckfoot sweep, placed at a distance of 0.2-0.3 m and followed by pressure wheels to close the injection slits.

Shallow injection resulted in a similar reduction of ammonia emission to tine injection, whereas shallow injection with open slits resulted in less of a reduction. In general, shallow injection techniques appeared to be less suitable for grassland on peat soils and heavy clay soils, because of the risk of sward damage and the poor bearing capacity of these soils for the heavy machines. The N-utilization of slurry applied by shallow injection with open and closed slits on sandy soils almost doubled in comparison to surface spreading ('Table 2).

Band spreading by trailing feet
Application of slurry by means of band spreading by trailing feet (coulters) was developed as an alternative to injection techniques. With this technique, slurry is placed just on top of the soil in strips at a distance of 0.2 m apart. Using this method, ammonia emission is influenced by the



amount of slurry applied and the height of the grass. It is lowest if relatively small quantitities (8-10 m^3 slurry/ha) are applied to fairly tall grass (Table 1). In addition, equipment is available which can apply slurry either by injection with open slits and/or band spreading by trailing feet, depending on the suitability of the soil and weather conditions.

Dilution of slurry with water
Dilution of slurry with water results in a lower ammonia concentration and a better penetration into the soil. Mixing ratios of 1:3 are needed to reduce the ammonia volatilization substantially. The variation in the reduction of the ammonia volatilization is large. On average, the volatilization of ammonia was reduced by 20-80% by diluting slurty 1:3. Recently, a special technique with a spray beam has been developed to mix water and for sutface spreading of diluted slurry. Special devices were developed to maintain a constant water/slurry mixing ratio and for verification of the mixing ratio. The advantages of this system are that slurry can be applied earlier in spring with less damage to the sward on grassland with a poor bearing capacity. At present the use of this system is temporarily permitted on peat grassland.
Sutface spreading of diluted slurry resulted in a better N utilization than of undiluted slurry. N-utilization, however, was lower than with tine injection or shallow injection with open slits (Table 2).

Irriga tion during and after slurty applica tion
Ammonia volatilization varied considerably with irrigation during and after surface spreading (Table 1) and therefore this method is not permitted. Grass should already be moist before application so that all slurry is removed and flushed into the soil during slurty application to obtain a substantial reduction of the ammonia emission.

Acidifica tion of slurry
Since 1989 research has been carried out with nitric acid as an additive to acidify slurty in the Netherlands. The ammonia emission from strongly acidified slurry (pH< 5) is reduced by 70-95% on application. The reduction is less and more variable at a higher pH (Table 1). Acidification of slurry can be done while in storage but also just before application. Acidified slurry can be applied by surface spreading but

band spreading by trailing feet is preferred as a better distribution of the slurry is obtained and to prevent smothering and scorching of the grass.
Research showed that for two out of three years, milk production during the grazing season was 1 kg per cow per day lower when cows grazed pasture where acidified slurry was applied by sut-face spreading compared to pasture where slurty was applied by shallow injection with open slits. When acidified slurry was applied by band spreading by trailing feet milk production was not affected. Moreover, because of verification problems, acidification of slurry is not recognized as a suitable low emission method.
The mineral N in acidified slurry appeared to act as efficient as N from fertilizer. When applied in spring N efficiency compared to fertilizer N (CAN-27) was somewhat higher (110%) than when applied in summer (90%).

Experiences in practice

Several new application techniques were tested on farm by means of demonstration projects. Advantages mentioned by farmers were: a better utilization of nitrogen and less fouling and scorching of the grass with manure. Sward damage owing to the heavy machinery and injection slits was a drawback farmers experienced on peat and heavy clay soils. By adapting tyre size and lowering tyre pressure much of the damage could be avoided. In general, on heavy clay and peat soils, dilution of slurty with water and the use of band spreading by trailing feet were preferred to injection techniques. In general, dairy farmers on sandy soils experienced few problems with slurty application by injection. Applying slurry by tine and shallow injection techniques in summer sometimes resulted in dessication or scorching of grass occurred along the injection slits, especially with dry conditions following application.

Slurry applica tion and na ture conservation

The prohibition on applying slurry during winter and the use of new application techniques could have a negative effect on the meadow bird population when slurry is applied during the brooding season. Calculations, based on experimental data, show that slurry can be applied by shallow injection with open slits to two thirds of the grassland area on sandy soils before the start of the brooding season. During this period, the bearing capacity of grassland on peat and heavy clay soils is often too poor. However, if wide tyres and low tyre pressure systems are used, slurty can be applied earlier to grassland on peat and heavy clay soils as long as draft requirements are low. Systems like the surface spreading of diluted slurry with a spray beam and band spreading by trailing feet have lower draft requirements than injection techniques. Under normal weather conditions, it should be possible to apply slurty with these techniques before the start of the birds' brooding season. Good experiences have also been gained in practice by involving volunteers to mark and to protect nests when applying slurry on dairy farms.

3.4 *Application techniques for maize land and their effectiveness*

A reduction of the ammonia volatilization from slurty applied to arable land can be achieved by applying and incorporating slurry into the soil immediately during slurry application. The ammonia emission can be reduced by 70-95 % by incorporating slurry at once compared to sut-face spreading (Table 1). This can be done with injection techniques. A larger variation in ammonia emission was measured when using methods incorporating slurry into the soil within 24 hrs after application for example by ploughing after surface spreading.

4. **Conclusions**

The desire of society in the Netherlands to reduce the negative effects of slurry on the environment has resulted in regulations concerning the amount of slurry to be applied, time and method of slurty application.
Several new application techniques have been developed for grassland en arable land. The use of these techniques result in a lower ammonia emission, a better utilization of nitrogen from slurry and as a consequence will result in a lower use of nitrogen fertilizer and lower nitrogen losses on dairy farms.
Slurty has become again a valuable nutrient in stead of a waste product.

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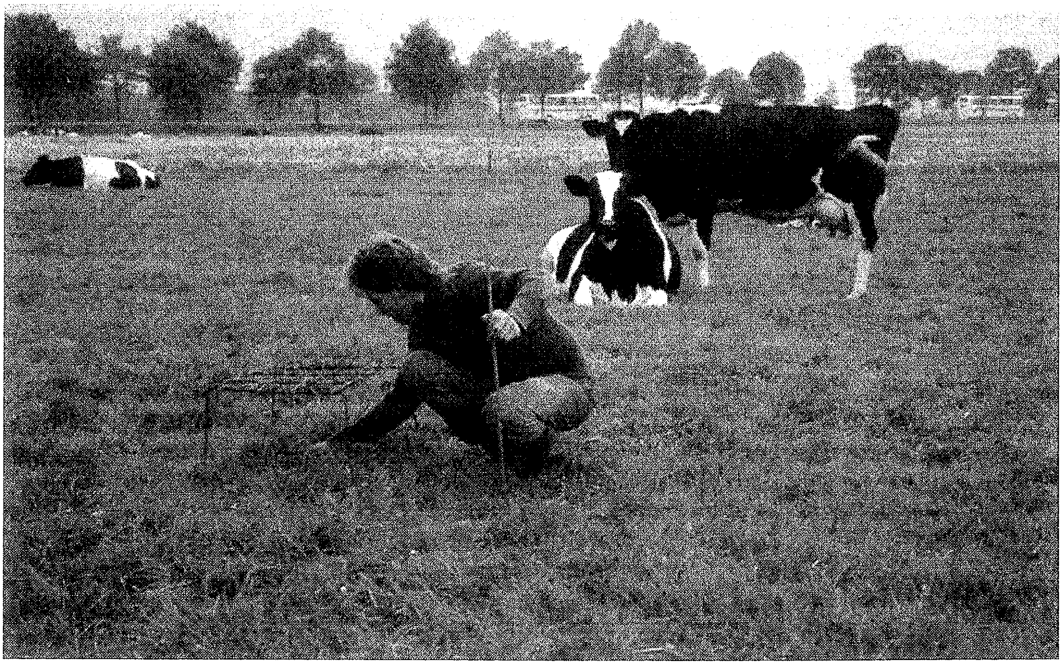


Photo: A. van Paassen

Towards a sustainable nutrient and plant protection management of maize

W. van Dijk (Research Station for Arable Farming and Field Production of Vegetables PAGV-Lelystad)

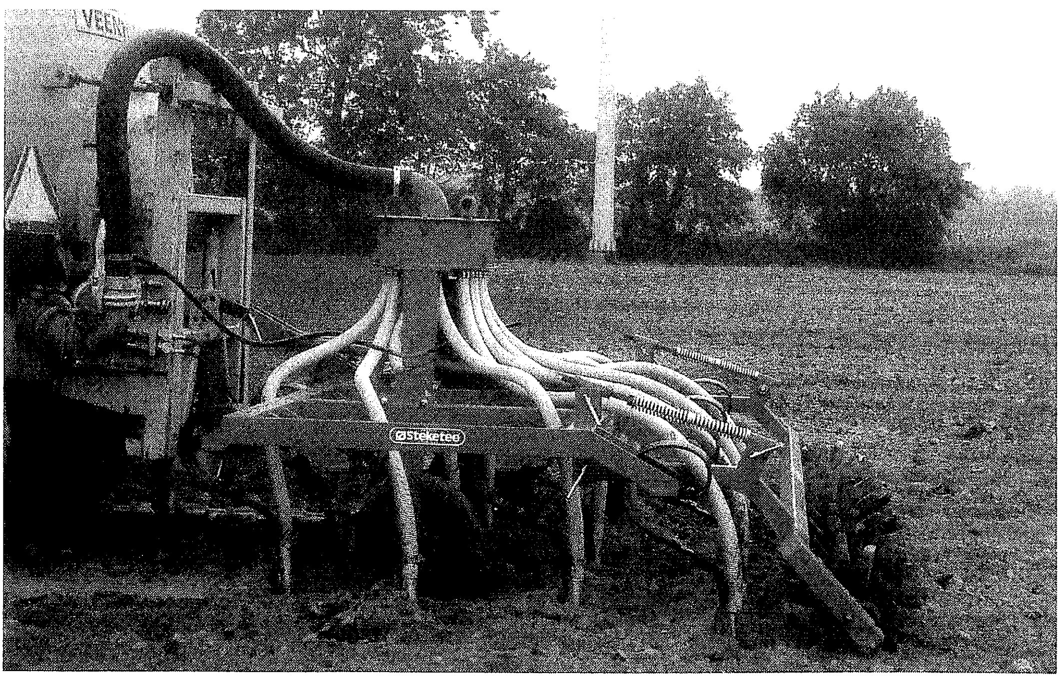
Abstract

Maize growing has become associated with low nutrient utilization and excessive herbicide use. Nutrient utilization can be improved by adjusting fertilizer input rates and the time and place of their application to soil and crop characteristics. Residual N left in the soil in the autumn can be taken up by catch crops. Chemical weed control can be substituted by mechanica1 weed control. Additionally, dose and timing of chemical treatments can be adjusted to weed development, resulting in reduced input. The contribution of crop rotation to nutrient management and weed control is discussed. A sustainable crop management means, however, that maize growers should pay more attention to crop husbandry.

1 Introduction

Maize area in the Netherlands covers about 245,000 ha and is therefore, after grass (about 1 ,OOO,OOO ha) the most important fodder crop. On a small scale lucerne and fodder beets are grown, 6,500 and 2,000 ha (respectively). A small part of the maize area (about 10,000 ha) is harvested as corn cob mix and grain maize. To a considerable extent (60-70 %) maize is grown on cattle farms.

The popularity of maize can be attributed to its stable yield and quality, its relative, simple cropping technique and its tolerance to high cropping frequency and excessive manure applications. However, maize growing has become associated with nutrient emissions and herbicide emissions and resistance. This paper presents a review of measures to improve nutrient utilization and to reduce the use of herbicides.



Injection of slurty is preferable to aboveground spreading because of the more homogeneous distribution

Table 1 Nitrogen-recommendations for maize in the Netherlands

Manure use[1]	High	Low
Advised N-rate (kg/ha)		
- early spring (0-30 cm)	180 - Nmin[2]	205 - Nmin
- late spring (0-60 cm)	210 - Nmin	210 - Nmin

[1] high = about 40 m^3/ha/year
low = about 10 m^3/ha/year
[2] soil mineral N

2 Nutrient utilization

Nutrient utilization by maize is low compared to cereals, grass and fodder beets. This can be ascribed to several reasons. First, especially on intensive livestock farms, manure applications often exceed crop demand. Furthermore, the frequent use of high amounts of manure increases the N-mineralization potential and the P-content of. the soil, resulting in low recoveries of applied nutrients. Finally, nutrient utilization is also impeded by certain crop characteristics, such as an early cessation of uptake during the growing season and an incomplete exploration of the soil during early growth.

2.1 *Fertilizer input*

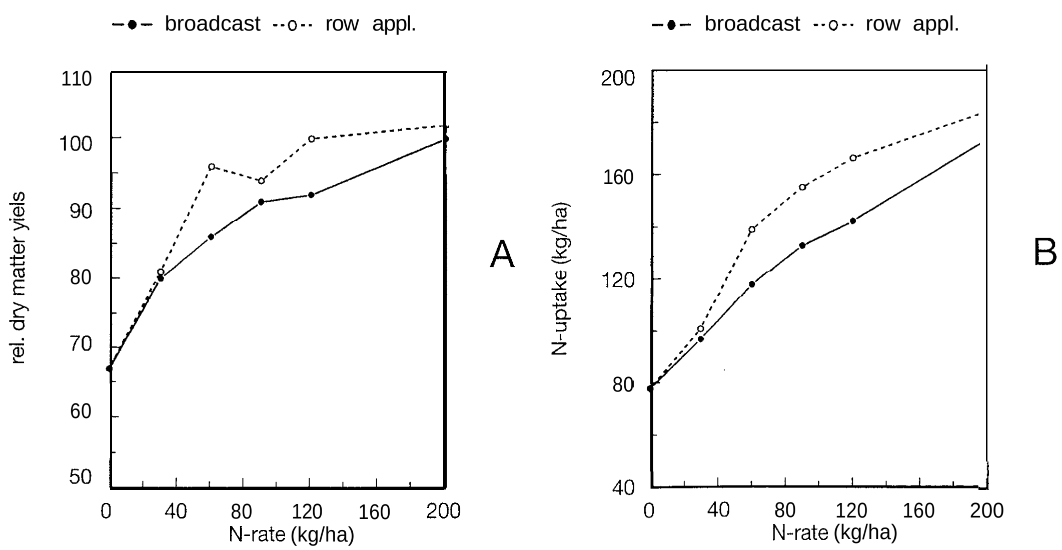
Nutrient utilization can be improved by adapting nutrient inputs to crop and soil demand by using current nutrient recommendations. In 1991 new recommendations were developed for nitrogen based on soil mineral N in spring and early summer (Table 1). To adapt the N input to the N-supplying capacity of the soil during the growing season, a distinction is made between soils with a high and low N-mineralization level caused by differences in manure use. The sampling in early summer can be seen as a correction possibility when doubts arise about the N-availability, for example after periods with high amounts of precipitation or when the crop turns yellow due to low temperatures or N-deficiency.

The frequent use of high amounts of manure has also increased soil P-status. At this moment, a substantial part of the maize land is P-saturated causing leaching losses to ground and surface water. From an environmental point of view but also when P-fertilizer recommendations are taken into account, in order to lower soil P-levels (these soils should not be fertilized anymore). However, this will of course increase the problems of manure surplusses. At high soil P-levels the use of P-starter fertilizers is not profitable anymore and should therefore be abandoned.

2.2 *Timing of fertilizer applica tion*

Nutrient utilization can also be improved by optimizing synchronization of nutrient application and crop demand. Therefore, nutrient application should be postponed until late spring. On sandy

Figure 1 Relative dry matter yield (A) and N-uptake (kg/ha) (B) of silage maize as affected by N-rate and application method (broadcast or row appplication) on a sandy soil (mean values for 1992-1994)



soils, where the major part of maize is grown, this is already practice. However, on fine textured soils manure is generally applied in the autumn in order to protect soil structure. To avoid early losses nutrients should be immobilized with cereal straw or cover crops. However, by doing so mineral N is converted into organic N which generally leads to a lower utilization than spring applied mineral N. This is owing to a suboptimal synchronization of remineralization and crop demand. For this reason research has (recently) been started to investigate the possibillities of applying manure in spring on fine textured soils as well.

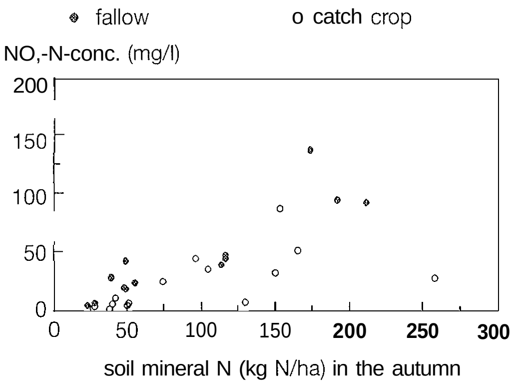
A deliberate split application of nitrogen, which is common in cereals, is not advised. From former research it could be concluded that a split application of N resulted in a lower utilization. Apparently maize (already) needs a high nutrient availability during juvenile growth.

2.3 *Placement of fertiiizers*

During the first 4-8 weeks after emergence exploration of the soil by maize roots is rather poor. Therefore, positive effects on nutrient utilization have been achieved by placing fertilizers next to the row. Figure 1 shows some results of recent N placement research in the Netherlands. Compared to broadcast application, row application of N resulted in an increase in dry matter yield and especially oin N-uptake. In addition, N-recovery is strongly increased by row application. Therefore, row application of fertilizers seems to be an effective was of reducing environmental losses. At this moment, row application of N and P starter fertilizer is rather common in practice.

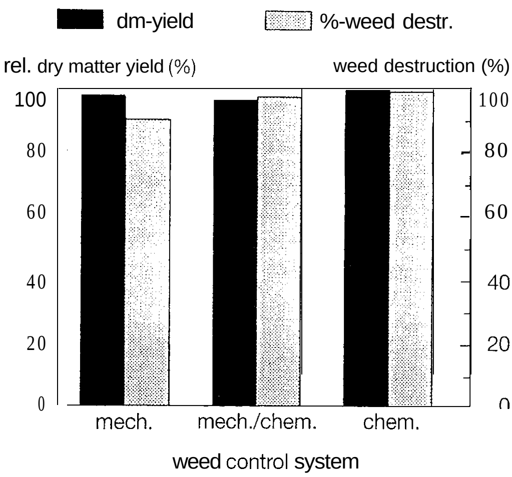
Maize is for a major part fertilized with manure. Manure should be applied sufficiently deeply to

Figure 2 NO,-N concentration (weighted mean, October-March) at 1 m depth as affected by N-rate on preceeding maize crop with and without a cover crop (mean values for 1988-1993)



Interrow weed control in maize by hoeing

Figure 3 Relative dry matter yield of silage maize and percentage weed destruction as affected by several weed control systems



avoid volatilization but not too deeply, in order to allow for a timely interception by roots (about 8-10 cm). Injection is preferable to aboveground spreading because of the more homogeneous distribution. Recent research has also shown positive effects of row application of manure. However, row application of manure instead of artificial fertilizers is technically more complicated.

2.4 *Catch crops*

After the maize harvest, winter catch crops can also contribute to a higher nutrient utilization by taking up a part of the residues, resulting in lower N leaching losses (Figure 2). However, compared to cereals the late harvest of maize restricts the N-uptake of catch crops to about 30-40 kg per ha. To avoid early losses, catch crops should preferably be winter hardy and be left intact until the following spring. This restricts the choice of cover crops species to winter tye and undersown grass. Fut-thermore, the effective nutrient input from incorporated cover crops should be deducted from the advised N-rate. If not, losses are only delayed for one year.

2.5 *Gro wing conditions*

Nutrient utilization can also be increased by creating optimal growing conditions for root exploration of the maize crop. Soil compaction should be prevented or alleviated. In regions with unfavourable climatic conditions, or on cold, wet soils farmers should consider abandoning maize growing or at least postponing planting date until soil moisture has decreased and soil temperature increased.

2.6 *Crop ro ta tion*

Optimal growing conditions can also be achieved by crop rotation. In the Netherlands, for practica1 reasons, maize is mainly grown continuously on one and the same field. However, yields of continuously grown maize are 10-20 % less than maize grown in rotation with arable crops such as potatoes, sugar beets and cereals. This is owing to the incidence of root rot. An effective control of root rot by means of crop rotation can be favourable for nutrient utilization.

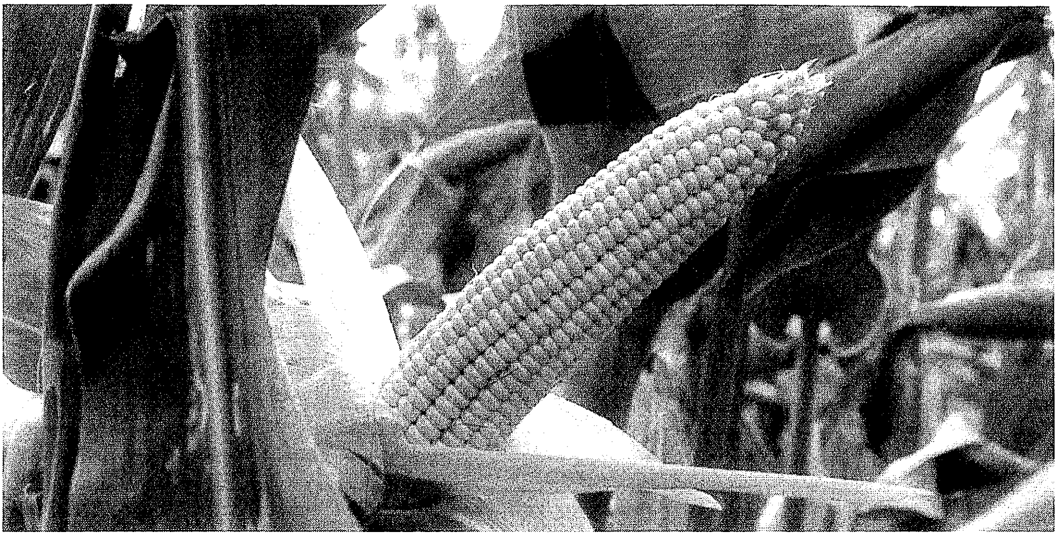
Crop rotation on dairy farms (is) often only possible by alternating maize with grass. However, this can lead to unacceptable nutrient losses, especially nitrogen, caused by uncontrolled mineralization when grass is ploughed up.

Nitrogen mineralization after ploughing up pastures can be expected to be reduced by restricting the age and the N-fertilization level of the pasture. Furthermore, ploughing up pastures in spring instead of autumn will also decrease losses. Finally, N-rates of the following crop should be adjusted. This means that a greater part of the manure must be applied on grassland. However, even when maize is grown at an adjusted N-rate, problems may arise because the utilization of nitrogen by maize depends strongly on timing and placement of fertilizers,

Table 2 Strategies to reduce herbicide use in maize

Crop stage	Strategy		
	mechanica1	mechanical/chemical	chemical
planting	harrowing	harrowing	low dose
4-5 leaf[1]	hoeing/ridging	hoeing/row spraying	low dose

[1] fully expanded leaves



which are difficult to realize with an incorporated pasture. Moreover, N-uptake by maize generally ceases after flowering which means that the nitrogen mineralizing in late summer will not be taken up by the crop anymore and will therefore contribute to leaching losses. For this reason it seems essential to grow catch crops after maize or to grow fodder beets instead of maize in the first year of ploughing up pastures.

3 Crop protection

3.1 *Weed control*

The frequent use of the herbicide atrazin for weed control in maize, in combination with continuous cropping resulted in leaching losses to the groundwater and selection of atrazin-resistant weed species. The latter caused an increase in herbicide use to approximately 2-2.5 kg a.m. per ha. In 1995 and 2000 herbicide use must be reduced to respectively 1.3 and 1 .O kg a.m. per ha. Therefore, strategies have been developed to reduce the use of chemicals.

Weed control should first be based on prevention. Dispersal of weed seeds should be avoided by using clean machinery. Furthermore, research has shown that contaminated fodder and manure should be conserved and stored for at least three months in order to kill weed seeds. Farmers can also consider pre-planting weed control, possibly at the expense of early maize planting.

After planting of the maize, different weed control strategies can be chosen (Table 2). Owing to the wide row spacing of maize, herbicides can partly or even totally be substituted by mechanica1 methods. Mechanica1 weed control consists of several harrow treatments followed by inter-row treatments (especially hoeing) combined with ridging to control weeds in the row. Under unfavourable weather conditions, ridging can be substituted by row spraying. Figure 3 shows that weed control can be effective and that maize yields are slightly lower compared to chemical weed control.

Farmers can also choose low dose spraying. The first results of applied research concerning this topic are promising. Especially on fine textured and frost-sensitive soils, where mechanica1 weed control can easily pose problems, low dose spraying seems to be a good alternative. For all strategies it is necessaty to check the fields regularly in order to control weeds at their most vulnerable stage.

Mechanica1 control of perennial weeds is only effective by repeated cultivator treatments on fallow land in dry periods. As maize is harvested rather late, this can only be achieved by rotating maize with crops that are harvested early, for example cereals.

3.2 *Crop rotation*

Crop rotation of maize with other arable crops can facilitate weed control in maize due to prevention of selection of atrazin-resistant weed species. However, on dairy farms, when maize is grown in rotation with grass the positive effects on control of annual weeds are doubtful owing to the persistance of weed seeds in undisturbed grassland. Perennial weeds can, however, be exhausted during a period of grass by frequent mowing or grazing.

3.3 *Pests and diseases*

Pests and diseases in maize, if they occur, are not controlled chemically in north-western Europe. The only exception is a pesticide coating of the seed and occasionally, a treatment against wireworms when maize is preceded by permanent pastures.

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Feeding management to improve nitrogen utilization

R. Meijer (PR-Lelystad)

Abstract

Feeding management can be used as a tool to help control environmental pollution. The challenge is to add environmental considerations to the ration formulation process with continuing to formulate balanced rations that support efficient and profitable animal production. Improvement of N utilization on dairy farms can be achieved by a decrease in dietary N level while productivity is maintained constant. In dairy systems mainly based on grass or grass silage, reducing the dietary N level can be achieved by a lower N content of grass or grass silage owing to a reduced fertilization level or by supplementing with feedstuffs with a relatively high energy and low protein content. Improvement of N utilization by a reduced N fertilization level on grassland is limited to a certain level, because experiments have shown that low levels of N fertilization have negative effects on production performance due to a reduced feeding value and feed intake. Partial replacement of grass or grass silage by maize silage or supplementing with high energy and low N feedstuffs like maize cob silage or beet pulp improve N utilization without negative effects on production performance. In addition, these replacements are useful in grass or grass silage based diets with regard to N utilization. At farm level, further improvement in N utilization can be achieved by a higher production level per cow. Current research is directed towards further improvement of N utilization by matching rates of rumen degradation of proteins and carbohydrates and by balancing the amino acid supply.

1. Introduction

Under Dutch feeding regimes 15 to 25% of the N ingested by dait-y cows is recovered in milk or meat. Approximately 75 to 85% of the N ingested by dairy cows is excreted in faeces and urine. A considerable part of the nitrogenous compounds in manure get lost and cause environmental pollution due to ammonia volatilization and nitrate leaching. In order to minimize the losses of nutrients to the environment we have to aim at a high level of nutrient utilization. Nutritional management can be used as a tool to help control environmental pollution.

Improvement of N utilization can be achieved by reducing the dietary N input while productivity is maintained constant. An important site of N losses in ruminants is the rumen, mainly as a result of a surplus of rumen degradable protein. Recognition of these losses is facilitated by a newly developed protein evaluation system that offers the opportunity of preventing avoidable losses.

Under EC-quota conditions, fut-ther improvement in N utilization at farm level can also be achieved by a higher production level per cow due to decreasing the relative losses in maintenance and a reduction in the number of cows per hectare. Both approaches will consequently result in a reduced excretion of N in animal manure.

The objective of this paper is to discuss the options for improving N utilization by reducing the N-input and by increasing the production level in order to improve the sustainability of modern dait-y farming systems.

2 Reduce N input

A reduction in dietaty N input can be achieved in several ways. The new protein evaluation system used in the Netherlands, the DVE/OEB system, offers the opportunity to prevent avoidable losses of N by feeding according to more exactly defined protein requirements of daity cows. In this system, the protein supply and demand is being expressed as intestinal digestible protein and is called DVE. The OEB value, which is called the rumen protein balance, indicates whether there is a surplus or a deficit of degradable protein in the rumen and can be used as a tool to help control environmental pollution. When positive, the OEB-value gives the loss of N from the turnen. When negative, microbial protein synthesis may be impaired, because of a shortage of N in the rumen.

Grass or grass silage based diets contain between 180 and 240 g CP/kg DM and a relative high surplus of degradable protein. These high levels of protein are mainly a consequence of high rates of N fertilization (300-400 kg N/ha/yr). The protein content of grass and grass silage can be reduced by lowering the high level of N fertilization. Another way to reduce the N content of the diet is supplementation of grass with low protein forages like maize silage or low protein concentrates like beet pulp, fodder beets, maize cob silage or cereals. The deficit of N in these supplements can easily be balanced by the surplus in grass resulting in an improved N utilization.

2.1 *Reduce level of N fertilization*

After introduction of the milk quota system in 1984, most dairy farmers had a surplus of forage, hence a lower productivity of the grassland seems possible and justified. In practice from 1984 onwards, the input of N by fertilizers and concentrates continously decreased. Reducing the rate of N fertilization, under practica1 conditions resulting in a prolonged cutting interval, not only results in a reduced N content of grass but also will reduce its nutritive value and as a consequence reduce grass intake. Feeding experiments were carried out in order to study the effect of a lower fet-tilization level of grassland on feed intake and production performance. Results of zero grazing experiments showed that when the level of N fertilization was reduced from 300 to 150 kg N/ha/yr N utilization increased from 21 .1% to 26.5% (equal dm/ha) or 23.4% (equal cutting interval). However poduction performance was negatively influenced owing to the reduced nutritive value of the grass. This negative influence on production performance could be diminished by a reduced cutting interval. Experiments with high-N and low-N grass silages gave similar results, an improved N utilization on low N grass silage, while production performance was reduced owing to a lower energy value and dry matter intake and consequently a reduced energy intake.

2.2 *Partial replacement of grass or grass silage by lo w pro tein forages*

Several experiments were carried out to investigate the effect of pat-tial replacement of fresh grass with low protein forages (maize silage) on N utilization. Results of experiments with partial replacement of herbage with maize silage showed that N utilization significantly increased from 18.2% to 24.8% while production performance was maintained constant. Experiments with partial substitution of grass silage for maize silage also showed considerable increase in N utilization without negative effects on feed intake and milk production.

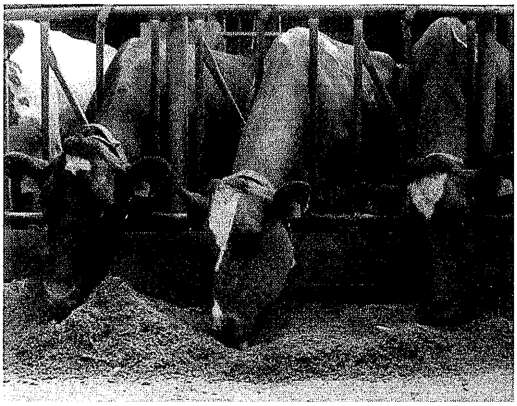
2.3 *Supplementation with low protein concentrates*

Several feeding trials were performed to study the effect of inclusion of low nitrogen concentrates such as fodder beets, beet pulp or maize cob silage in grass or grass silage based diets, on N utilization and production performance. Experiments with fodder beets showed an improved N utilization (5-10%) but due to the higher substitution rate of fodder beets, dry matter intake and energy intake were reduced and as a consequence production performance was negatively influenced. Replacement of compound feeds with dried beet pulp showed an increase in N utilization from 26.3% to 30.3% with no negative effects on production performance. Partial replacement of compound feeds with maize cob silage (3.5 kg dm) improved N utilization from 28 to 32.2%, while milk fat content tended to be lower with maize cob silage. However there was no difference in production of Fat and Protein Corrected Milk.

3 Increase in production level per cow

With regard to environmental pollution several studies have shown that the utilization of nitrogen at farm level under EC-quota conditions can be improved by higher milk yields per cow due to which the number of cows required to produce the herd quota are reduced. Consequently, the number of cows per ha, the required amount of forage and the amount of manure produced, decreased leading to an improvement in N utilization.

To test these calculations we stat-ted a dairy herd in order to achieve a very high production level per cow and a high level of nutrient utilization. The final goal is to realize a production level per cow of up to 10.000 kg/yr with an average protein content of at minimum 3.50%. As a feeding strategy phase feeding with production groups is applied in order to provide cows with diets that encourage economical and optimal milk produc-



tion and to optimize nutrient utilization. In order to improve the prediction of feed intake for the formulation of balanced diets, specially for cows with a high production level, individual feed intake of individual cows is daily registered by a Roughage Intake Control system. To collect information during the whole lactation, cows were kept indoors during the whole year. In 1994 the average production level in 305 days was 9743 kg Milk with 4.35% fat and 3.51% protein. First results of the feed intake of cows with a high production level showed that the observed feed intake is higher then the predicted feed intake according to the Dutch cow model. With the used feeding strategy and a good quality roughage the consumption of concentrates was about 26 kg dm/1 00 kg FPCM. This is about 4 kg less then the concentrate consumption on farms in practice with a comparable production level. The efficiency of N utilization on this farm is rather high, about 25% of the dietary N input recovers in milk.

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Sustainable dairy cows

W.J.A. Hanekamp (PR-Lelystad)

Abstract

For sustainable daity farming control of health and reproduction management is necessary. Registration of diseases at 9 experimental farms shows considerable differences between the farms. The visual obsetvations and interpretation of the farmer is important. Meaningful parameters on farm and animal level are necessaty. It is showed that high yielding cows should be inseminated later. Furtheron somatic cell count can not predict clinical mastitis. To find patterns in somatic cell count measurement every monthly milk recording is needed. Automatic recording of milk production, conductivity, temperature and activity may be helpful for health and reproduction management because of objective and mostly continue registration.

1. Introduction

For sustainable daity farming control of health and reproduction of dairy cows is necessaty for which the management cycle can be used. This means: planning, operation and control. During so requires registration and management parameters. Parameters may be herd averages parameters but also the variation between animals may be useful. Parameters support the farmer to take action to realize his planned targets. A proper health and reproduction management gives a better animal welfare, a reduction in the use of medicins, less mineral losses and a higher income. This article gives a review of analyses on diseases, fertility parameters and somatic cell counts in dairy cows based on research at PR. It is stressed that for management meaningful parameters at farm and animal level are necessary.

2. Farm differences in average disease incidence

At 9 experimental farms belonging to applied research a herd management system was installed at 1988. On average there were 755 cows at the nine farms. Farm size varied between 46 and 123 cows and percentage of heifers varied between 20 and 42 with an average of 30. Reproduction, animal health and milk production data of all dairy cows were registrated and brought into the computer daily. Milk production data were registered automatically. In a protocol standards were defined for diagnose coding (both for farmers and veterinarians) and treatment coding. Every week an export of the last updates was send to the central research station at Lelystad. Data were regularly checked on consistency and logical values.

In table 1 average incidence for failures in heat detection mastitis, leg problems and milk fever are summarized for the nine experimental farms from during five years (1989-1993). The incidence is calculated as the number of cows which got at least one time in a year the disease relative to the number of average present cows per year. Failures in heat detection are most frequent, followed by mastitis and leg problems. Mastitis however has a greater economic loss than reproduction and leg problems.

Daily milk yield data from about 100 cases of clinical mastitis from the experimental farms were used to calculate the daily production before and after the occurrence of clinical mastitis. Results

Table 1 Average incidence of disease (in % of total number of cows) at nine experimental farms during 1989-1993 with minimum and maximum for one year

Disease	Average	Minimum	Maximum
Reproduction			
No heat	20	8	59
Endometritis	11	1	28
Udder			
Mastitis	20	2	43
Legs			
Sole ulcera	15	0	39
Metabolic diseases			
Milk fever[1)]	20	4	61

1) only 2nd calf and older

show that the production loss is considerable, almost 10 liter per day. The realised production 20 days after the mastitis still is 3 liter per day less than was expected.
The rate of disease cases during lactation is of interest for fertility. There seems to be a very high peak just after calving. At the experimental farms about 40 percent of the diseases occur between 10 days before and one month after calving.

Table 1 also shows that there are considerable differences between the experimental farms. However it is not easy to draw conclusions from these differences because the number of farms is small. Besides the influence of the farmer is also very large. Of corse every farmer pays attention to his cows but the intensity is not always the same. Fut-theron the farmer has to interpreted the signs and hereby his self-confidence is important.
To get a better view on the real health of the cows more objective measurements are necessary. The daily milk production of course is a very important parameter and should be combined with temperature and conductivity which can automatically be measured in the milk. For heat cow activity can be measured by foot or by neck. At the experimental farms these measurements will be done and combination of the data will possibly be useful to detect sick animals better.

3. **Farm differences and within farm differences for fettility parameters**

Many parameters to describe fertility can be calculated. The interval between calving and first insemination can be used as a measure for cyclicity. A widely used figure to describe the success of inseminations at herd level is the non return percentage 56 days after insemination. In daily practice herds are often compared for fertility by means of calving interval.

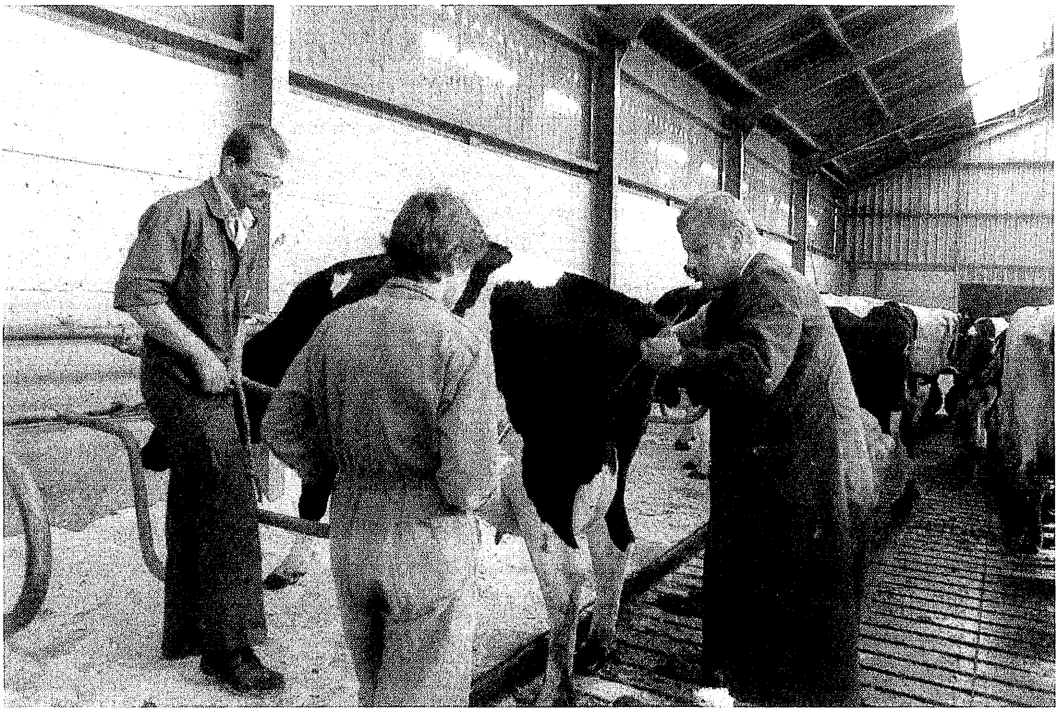
Table 2 Herd averages for fertility parameters for three levels of milk production

Production (305 days) (kg)	6300	7700	9200
Calving interval (days)	382	383	385
Interval calving 1 st insemination (days)	80	80	78
Number of inseminations	1.61	1.63	1.82
Pregnant after 1 st insemination(%)	48	45	40
Non return after 56 days (%)	69	67	61

Table 3 Average for fertility parameters for two levels of milk production within herds between cows

Milk production (305 days) (kg)	< -750	> +750
Calving interval (days)	372	396
Interval calving 1 st insemination (days)	74	83
Number of inseminations	1.54	1.90
Pregnant after 1 st insemination (%)	49	37
Non return after 56 days	68	61

From the national milk recording database a sample of 350 farms was obtained with a total of 30,000 records in three years (1988-1991). Lactation and insemination records from individual cows from these farms were used to study the relation between production and fertility parameters between and within herds.
Table 2 gives some reproduction parameters related to the average milk production on herd level. Milk production is calculated as the 305 day production according to the rules of the Royal Dutch Cattle Syndicate (NRS). From the table it can be concluded that there is no strong relation between average milk production and reproduction at herd level. Both at high and low productive herds insemination is started about 80 days after calving. There is also no substantial difference in calving interval. Remarkable is that at higher producing herds more inseminations are needed which results in almost the same calving interval. This can indicate that heat detection is better at high producing herds. Non return after 56 days is an optimistic estimation of the real percentage of pregnancy after first insemination.
Between some fertility parameters there seems to be a certain relationship. The correlation between interval calving first insemination and calving interval is 0.79 which means that herds where cows are first inseminated early have longer intervals between first insemination and conception. Besides they also need more reinseminations. As correlation between number of inseminations and non return 56 days after first insemination is higher than 0.90 this indicates that they are almost the same variables.
The same dataset was also used for the relation between production and reproduction on cow level. Table 3 summarizes the results. One group has a production of 750 kg less than the average of the herd whereas the other group has a production of 750 kg above average. In contradistinction to the production on herd level



For animal health management registration is necessaty

there is a relation between milk production and fertility parameters within the farm. Cows with a high milk production have a longer calving interval, are inseminated later for the first time and need more inseminations and have a lower pregnancy percentage.

In an experiment at two of our experimental farms with 118 high yielding cows (8400 kg FCM) three times a week progesterone was measured in the milk from calving till about 50 days after calving. Almost 15 % of the cows had no oestrus cycle between 10 and 50 days after calving. It was found too that 28 % of the cows had a normal first oestrus cycle 26 days after calving. Nearly 60 % have a normal oestrus length in the second cycle.

A calving interval of 365 days is generally considered economically desirable and physiologically possible. As table 2 shows many herds however do not reach this figure. This can not only be due to a poor heat detection by the farmer as some cows do not have an oestrus within 50 days after calving and others have an irregular first oestrus. High yielding cows in every herd are in a negative energy balance at the beginning of their lactation and therefore it is difficult to come in oestrus. Besides farmers policy is important for the interpretation of the calving interval. How anxious will he be to get his high yielding cows pregnant. The high peak of diseases after calving causes high (veterinarian) costs. These peak costs are not fully included in the economic calculations of the optimal calving interval. So especially for high yielding cows a longer calving interval due to a planed delay of the first insemination after calving will be less deficit and acceptable.

4. **Wariation in somaticcell counts**

Mastitis is mostly an infection of the udder with bacteria. On this inflammation the cow reacts with a high somatic cell count which can routinely be measured every milk recording. A linear score is given to the farmers besides the absolute score. The linear score ranges is from 0 to 9.9. An attention is given when the linear score is greater or equal than 4.0, which is four times the normal value.

Data of about 900 cases of clinical mastitis at the experimental farms were used to study the relationship between clinical mastitis and somatic cell count. Conclusion was that clinical mastitis was hard to predict by high cell counts for cows. Only in 6 % of the cases it turned out that cows with a high linear score (>4.0) got clinical mastitis within one week. So a high somatic cell count can not be used to predict clinical mastitis. Besides 45 % of the clinical mastitis cases were around calving (dry period and first 25 days). No test milk recording has taken place yet.

The defence in the udder against an infection with bacteria can lead to different patterns of somatic cell count: long high (bacteria remains), different peaks (S. aureus, S. uberis), one peak (E. coli) and permanent low (bacteria has gone). Subclinical mastitis is defined as a high somatic cell count (~500.000) and the presence of bacteria.
Individual cow data from 4300 farms of the national milk recording database were used to describe the variation in somatic cell count. The dataset consist of almost 34.000 lactation having at least 8 somatic cell counts. At a certain milk recording 30% cows get an attention (linear score > 4.0) but half of these cows do not have an attention the next milk recording one month later. So due to this variation somatic cell count should be measured evety milk recording (3 or 4 weeks) to find patterns.


High yielding cow within a herd has a higher calving in terval

Farmers get a lower milk price if the milk they deliver has a cell count higher than 400.000 cells per ml. More than 100.000 bulk tank cell counts from a dairy plant collected at monthly intervals were analyzed. Just as for somatic cell counts there was a considerable variation in bull tank cell counts too and therefore it is difficult to predict the next bull tank cell count with an acceptable accuracy. Average bull tank cell count has to be lower than 200.000 for being in the no risk group. A high bull tank cell count is mostly a farm problem and can not be solved be selling some cows with a high somatic cell count at only one milk recording. To lower bulk tank cell count more attention should be paid to milking machine, milking technic and treatment of mastitis.

5. Conclusion

Also for health care the management cycle can be used. For diseases which are commonly on most dairy farms there are hardly any objective criteria so visual observations and interpretation of the farmer will be important. Variation between cows at a herd should be taken into account. Useful parameters should be specific (detect a normal situation good), sensitive (detect an abnormal situation good) and of economic impot-tance. Use of more automatic recording may be helpful to support health and reproduction management of the daity farmer.

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Reduction of ammonia emission from cubicle houses and slurry storage

M.C. Verboon (PR-Lelystad)

Abstract

The government aims to reduce ammonia emission by 50 to 70 percent between 1980 and 2000. Cattle housing and manure storage areas contribute approximately 30 percent to the total emission from cattle. This amounts to an average of 8.8 kg ammonia per daity cow during winter season.
Research on farm buildings to reduce ammonia emission is geared towards the rapid removal and storage of urine. This can be achieved using a sloped floor that facilitates fast run-off. The creation of slippery conditions for cows must be prevented. Another technique is the use of water to dilute the urine and flush the floor. This is effective but requires too much water. Acidification, by applying nitric acid to the manure in cellars below cubicle houses is another field of research. It is crucial that all the slurry stored should be kept at the required pH level to avoid nitrogen losses through denitrification. Acidification of manure decreases emission during storage outside the cellars as well as during application. Roof constructions or floating covers on slurry storages outside the cattle houses reduce the emission of ammonia considerably. These strategies are costly. The use of chopped straw as a cover is effective as well, but much cheaper.

1 Introduction

1.1 Ammonia emission

The ammonia emission problem is looked at in three ways, originating from livestock buildings, manure storage areas and during and after manure spreading. The estimates are that there is approximately 140 thousand tons ammonia originating from bovines per year with about 30 % from buildings and manure storage, 20 % from cattle on pasture and 50 % from manure spreading.
Ammonium is mainly formed through hydrolysis of urea excreted in urine and is in equilibrium with the volatile form ammonia. This process generally starts within half an hour and runs very fast on floors. Many species of micro-organisms produce the enzyme urease and are active in the feeding and dung passages and in faeces. The rate of volatilization is proportional to the emission surface, ammonia concentration, sutface temperature and ventilation. Total emission depends on the exposure time of the residues of manure on the floor. Reduction strategies are based on these principles. Aspects of animal welfare, economics and farm management will influence the adoption rate of the strategies. However, these aspects are not discussed in this paper.
An ammonia emission factor indicates the emission of ammonia from livestock buildings in kilograms per available animal place per year. Wherever faeces and urine are produced, collected and stored some of ammonia will volatilize. The amount can be calculated knowing what is the input of nitrogen and the output of nitrogen. In the case of cattle houses this was done for average Dutch cattle housing and feeding conditions. The input to the stable consists mainly of roughage and concentrates, the output mainly milk and manure. Table #.1 shows results of these calculations (1988). The data for dairy cattle and heifers are for a 190 day period running from November to May.

Later on these figures were confirmed in measurements during experiments both with mechanically ventilated and naturally ventilated cubicle houses. So, theoretically, reduction can be 8.8 kg ammonia per cow per winterperiod. In

Table 1 Ammonia emission factors for cattle

	Annual ammonia emission (kg/animal place)
Dairy cow[1)]	8.8
Heifer, 0 -2 years[1)]	3.9
Veal calf, 0 - 6 months	1.5
Beef bull, 0 -2 years	5.7

[1)] Winter season only

practice we shall encounter difficulties in accomplishing this.

Regulations to reduce ammonia volatilization from cattle houses have as yet not been formulated, as technical solutions are still under investigation. Recently, central government introduced a 'Green Label' for cattle houses. The label is awarded to buildings which reduce ammonia emission to below 50 percent of the defaults from table 1. Although a few designs are available, it turns out that the investments per cow are rather high at this moment. They can be used on a voluntary basis.

All outdoor manure storages built since 1987 must have an approved cover. From 2000 onwards this also applies to older storages.

1.2 *Cattle housing and manure storage conditions*

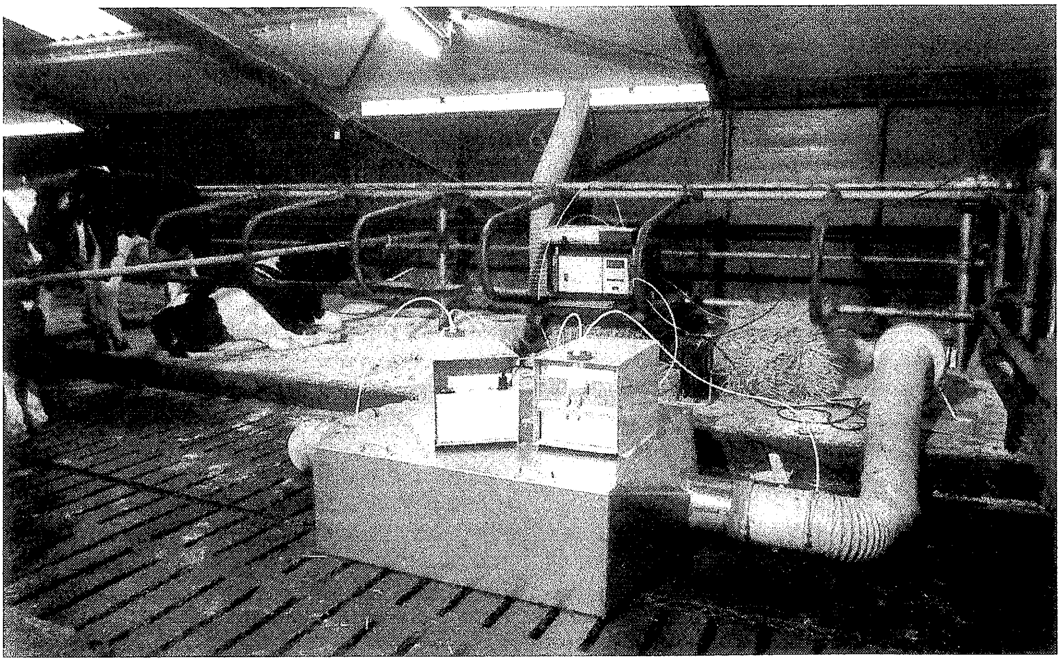
In 1992, there were 1.75 million daity cows and 1.55 million young stock in the Netherlands. About 85 percent of these animals are kept in about 25,000 cubicle houses, of wwhich 90 % with slurty cellars below a slatted concrete floor. About half a kg of bedding material (sawdust or chopped straw) on the concrete floor of the cubicle is required per animal per day to keep them as clean as possible. The other 15 percent of the cows is kept in a tied housing system. The buildings are, with a few exceptions, all naturally ventilated. This means that during the stallperiod the average temperature inside is about 10 °C (minimum 7 and maximum 13). This is about 5 °C higher than outside. On average roughage feeding consists of 70 % grass silage and 30 % maize silage.

Two thousand farms produce veal using 625 thousand animal places. Twenty thousand farms produce beef using 400,000 bulls. They are usually housed on a totally slatted floor system. There are two main systems for storage of liquid manure. The use of slurry cellars, which are interconnected for circulation and mixing is widespread. To increase storage capacity most farms use also slurry storages outside the buildings. By the end of 1992, storage capacity averaged 5.2 months or 17.4 million m^3. Circular above ground slurry storages are build for about 5.3 million m^3 with an average content of 700 m^3 per store.

2 Technical solutions to reduce ammonia volatilization

2.1 *Covering outdoor slurty storages*

According to research at the IMAG institute,



Measuring technic of ammonia emission with the Lindvall-box and NH_3-converters. Cows are displaced during measurement.

slurry store covers will reduce the emission of ammonia by between 46% and 86 %, depending on the type of cover used. The experiments included floating layers and constructed roofs. Natural floating layers, which were formed spontaneously, proved to reduce ammonia volatilization. It was difficult to maintain these layers. Further experimentation with lab scale tanks showed that addition of about 4 kg chopped wheat straw per m2 to the slurry stabilised the natural layer under all weather conditions. Ammonia emission decreased by 64% during the winter and by 71% during the summer. During 3 winters we were successful in creating a floating crust of chopped straw in slurry storages with capacities ranging from 450 m^3 to 1100 m^3. However, this method of covering is not approved by law because of problems with official control in practice. Recent research shows that the application of paraffin oil to the slurry surface reduces ammonia emission by between 50% and 75%, compared to no cover. Since the oil layer floats on manure, it can be used in cellars under the slatted floor.

2.2 *Slurty trea tment in cubicle houses*

Acidification of slurty

Acidification of slurry by adding strong acid shifts the equilibrium between ammonia and ammonium towards the non-volatile ammonium. As the most suitable acid we apply nitric (HNO_3) acid because nitrate is a plant nutrient. The main advantage is the reduction of ammonia emission at all stages of slurty treatment on the farm (stable, storage and application). We studied the effects of acidification of cattle slurry in a cellar under slatted floors between 1990 and 1994. Acid was added daily while mixing thoroughly. The pH value needed to be as low as 4.0 to keep loss of nitrate by denitrification below 5 %. The quantity of concentrated nitric acid (57 - 60%) needed, varied between 25 and 35 litres per m^3 of slurry, depending on the manure composition. Acidified cattle slurry has a mineral N content ranging from 4.9 to 7.7 kg per m^3 (3.3-5.2 kg NO,-N and 1.6-2.5 kg NH_3-N) which can be totally used for plant nutrition. Acidification of slurry reduced ammonia emission from the cellar by 50%. The emission from cubicle houses with slatted floor by acidification of the slurry in the cellar was about 30 %; that from the storage outside the building fell by over 90 %, whereas the emission during application was reduced by 85 %. The equipment required for acid storage, monitoring acid level, automatic addition of acid and mixing of slurry is expensive. However, this one operation can achieve an average emission reduction of 70 % per farm. The method has been used on a few farms but there is no admittance officially because it is not easy to control a proper use of the system.

Flushing of floors

The principle behind flushing is the dilution of the thin layer of manure residues on the feeding passage following scraping. Slatted floors are flushed by sprinkler tubes on both sides of the feeding passage. Sloping floors are flushed using a sprinkler equipped scraper. Results from an experiment on a slatted floor indicate that flushing using 12 litres of cleansing water per cow per day, immediately following each of 10 scrapings a day increased ammonia emission. Ammonia emission remained unchanged when using 25 litre of water per cow per day. IMAG-DLO achieved an emission reduction of 17% using 50 litres of water per cow per day.

PR has also conducted flushing experiments on its' Waiboerhoeve experimental farm with an unslatted floor. This floor has a slope of 3% and a slurry scraper equipped with spray nozzles. Use of a limited amount of water increased ammonia emission. Using 20 litres of spray water per cow per day reduced ammonia emission by 50%. In order to work well, flushing will strongly increase the amount of slurry to be stored and handled. Therefore, flushing seems only viable in cattle houses equipped with an unslatted floor, so that used flushing water can be recirculated following purification.

Sloped floors

Rapid run off and the continuous removal of urine, followed by covered storage diminishes the contact sut-face between slurry and air and therefore prevents ammonia emission. The floor of an unslatted walking area at the Waiboerhoeve has a slope of 3%. A gutter facilitates rapid transport of urine to the slurry cellar. Ammonia emission after scraping this floor was reduced by 50%, compared to an ordinary unslatted floor with similar measurements to the Lindvall box. Measurements in stables showed comparable reduction rates of 48 to 68%.

Frequent scraping is necessary to prevent faeces from blocking the gutter. This causes the floor to become slippery since it is wet again after drying.

This has a negative effect on animal welfare, as the sprinkler installation has to be used to prevent a dried crust forming on floors.

In a number of experiments, ready mixed concrete floors and prefab concrete floors were compared with epoxy coated floors. If the sloped floor was coated with an epoxy top layer, ammonia emission was reduced by up to 50%, when compared to an uncoated sloped floor. The additional effect of a coating is strongly dependent on the characteristics of the uncoated floor. Coating provided an additional reduction of only 23% when compared to a prefabricated concrete floor with a high density concrete top layer.

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Reduction of ammonia emission by a sloped floor (3%) with urine gutter.

Research on housing systems and manure treatment to reduce ammonia emission in dairy husbandry

J.H.M. Metz, N.W.M. Ogink and M.C.J. Smits
(Institute of Agricultural and Environmental Engineering IMAG-DLO - Wageningen)

Abstract

Compared to a reference cubicle house, the emission from a loose housing with feed cubicles was 10% lower and the emission from a tied housing system 28% lower. The reducing effect of replacing slats by a solid concrete floor that prevented the emission of ammonia from the underlying pit was approximately 50%. Flushing with water over slatted floors in a cubicle house reduced emission by 17% to 28%, applying 19 and 47 l water per day per cow respectively. Flushing, using 19 l per day per cow of flushing water with 4 g formaldehyde per litre, over a slatted floor resulted in a 50% lower emission. Acidification of slurry (pH < 4.5) in the pit under the slats reduced emission by 37%. A diet that contained a small surplus of Rumen Degradable Protein (RDP) resulted in a 39% lower emission rate, compared with a diet which contained a high surplus of RDP.

1. Introduction

The volatilization of ammonia contributes to eutrophication and acidification of natural ecosystems and thereby undermines their vitality. The amount of ammonia emitted by cattle husbandry in 1990 was estimated at approximately 55% of the total ammonia emission in the Netherlands. Dutch legislation aims at reducing ammonia emission in the year 2000 by 50% with respect to 1980. Sources of emission are application of slurry, animal housings, storage of manure and grazing. Currently, regulations are in force with regard to the storage and application of animal slurty. Legislative measures on housing systems have not been taken yet. On a voluntary basis, farmers are stimulated to invest in low emitting housing systems (so called Green Label systems). Green Label systems for cattle must have at least a 50% lower ammonia emission than the norm of 8.8 kg per cow per housing period of 190 days.

This paper presents some recent results in reducing ammonia emission in dairy husbandty through developments in housing systems, floor systems, manure handling and animal nutrition.

2. Methods for emission reduction in dairy husbandry

Practica1 concepts for reducing ammonia emission were based on theoretical factors in the process of ammonia formation and volatilization. In cow sheds ammonia is mainly formed by the breakdown of urea from urine by the enzyme urease. The volatilization rate of the ammonia produced depends on the concentration of ammonia at the emitting surface, temperature, air velocity, pH and size of the emitting sutface. Research on practica1 methods for reduction was carried out in mechanically ventilated housings, since operational methods for the measurement of ammonia emission from naturally ventilated houses were, until recently, not available. The measurement of ammonia was carried out by continuous monitoring of ventilation rate and sampling of exhaust air in which ammonia concentration was determined with an NO,-analyzer.

3. Housing systems

The ammonia emission from a loose housing system with slatted floor and cubicles, a loose housing with feed cubicles and a tied housing system were compared in an experimental cow shed. The first system was used as a reference. Compared to the reference the emission from the loose housing with feed cubicles was 10% lower and the emission from the tied housing system 28% lower. In the loose housing with feed cubicles a larger part of the faeces remained on the floor compared to the reference. More urine will be kept on the slats by these faeces which may result in a relatively higher emission from the floor, thus counterbalancing the effects of a restricted fouled area in the loose housing with

Table 1 Reduction of ammonia emission from a cow shed with different floor systems expressed as reduced proportions (NH, %) of the emission from a reference cow shed.

Floor structure	Finish on top side of floor	NH_3 (%)
slatted	no	
slatted	epoxy layer(6 mm)[1]	-3
solid, sloped V	epoxy layer(6 mm)	52
solid, sloped V	no	48
solid, sloped V	epoxy layer(2-3 mm)	49
solid, sloped V	mastic asphalt layer(25mm)	50
subfloor	no	24

[1] poly-urethane based resin on sides and bottom of slats

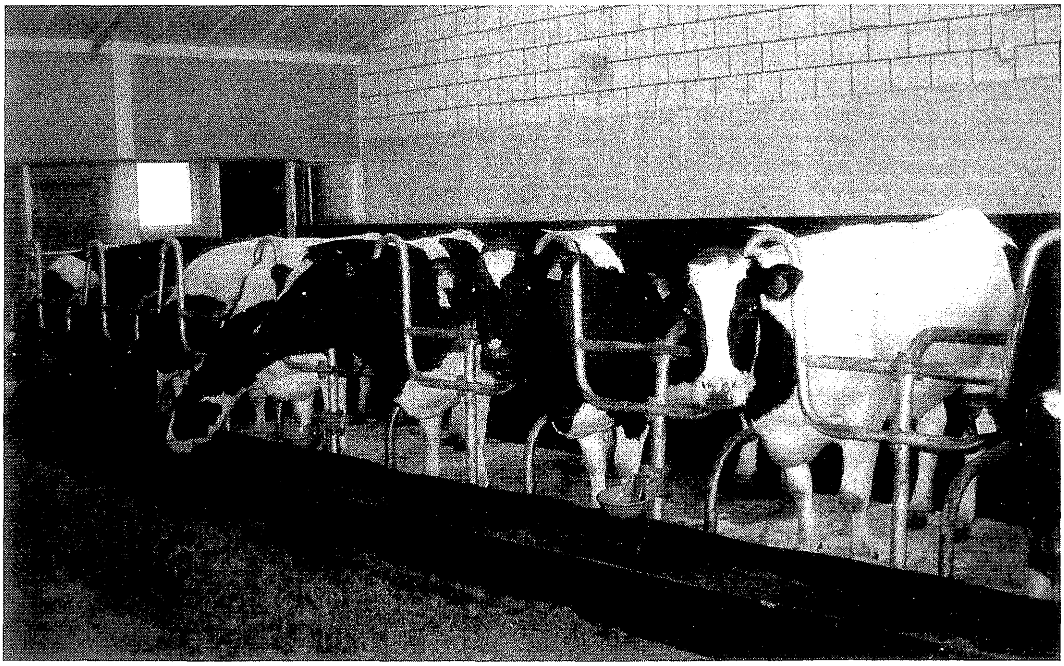
feed cubicles. In an earlier field study, an emission from a tying stall of only 2 kg NH, per winter season per cow was repot-ted. Compared to the normative of 8.8 kg for conventional loose housings, these earlier results suggest a much stronger reduction than found in the present experiment. Possibly the air flow over the slurty was at a much lower level in the field study compared to the present experiment, reducing the release of ammonia through the dung grid.

Floor systems

Floor structures that prevent ammonia emission from the underlying pit and floor finishes were investigated in a number of studies. The reducing effects of replacing slats by a solid concrete floor or constructing a solid subfloor below the slats were studied. All solid concrete floors were made up of prefabricated concrete elements, sloped in a V-design 3% to the centre and had a urine drain in the centre. The slopes were designed to drain off the urine as fast as possible. The solid floors were hourly scraped. The floor finishes were intended to keep ammonia emission at a low level and to improve the slip resistance of the floor. In Table 1 the reductions in ammonia emission compared to the reference cow shed with a concrete slatted floor without a finish, are given.

Manure handling

In table 2 the reductions of ammonia emission from a cow shed by different manure handling systems compared to a reference cow shed with a concrete slatted floor, are given. Systems for flushing with water over slatted floors in a cubicle house reduced emission by 17% to 28%, applying flushing volumes of 19 and 47 l per day per cow respectively. These quantities cause considerable increases in the slurty volume, resulting in extra costs of storage and land spreading. By adding disinfectants to the flush-



Experimental cow shed: loose housing with feed cubicles.

Table 2 Reduction of ammonia emission from a cow shed by different manure handling systems expressed as reduced proportions (NH, %) of the emission from a reference cow shed. Between brackets the corresponding 95% confidence intervals

Treatment	NH_3 (%)
flushing slatted floor	17
with 19 l water cow-1 day-1	28
with 42 l water cow-1 day-1	50
with 19 l water cow-1 day-1, including 4 g formaldehyde/l	
acidification of slurry in pit under slats (pH < 4.5)	37
acidification of slurry in pit under slats (pH < 4.5) and slats flooded every 3 hours	61

ing water that decrease urease activity on the floor and the top layer of the pit, both the reducing capacity may be increased and flushing volumes decreased. Flushing with formalin (4 g formaldehyde per litre) over a slatted floor resulted in a 50% lower emission, using 19 l per day per cow of flushing water. Tentative measurements of the indoor air, however, indicated that concentrations of volatilized formaldehyde should be lowered. Currently, research is being carried out to further minimize the amount of flushing water and the use of disinfectants.

By acidification of slurry in the pit under the slats, ammonia release from the pit may be prevented. Systems were developed to keep the pH level of the slurry below 4.5 by adding nitric acid. It was experimentally shown that such a system in a cubicle house with slatted floor could reduce emission by 37%. A fut-ther decrease in emission may be achieved by reducing the remaining emission from the floor sutface through flooding of the slats, during short consecutive intervals, with acidified slurry from the pit. In a preliminaty study on a combined acidification and flooding system in which slats were flooded every 3 hours for a few minutes, emission was reduced by 61% (Kroodsma, pers. communication). Attention has to be paid to the application of acidified slurry to grassland in relation to its relatively high nitrogen contents as a result of nitric acid addition.

Nutritional measures

In a model system of a cow shed a linear relationship between urinaty concentration of urea and ammonia emission was found. The urine samples used in this experiment were from animals that were fed different diets, and showed a wide range in the concentration of urea. In a subsequent experiment in 1993, effects of protein nutrition on urinary concentration of urea and ammonia emission were studied in a mechanically ventilated cubicle house with 34 lactating dairy cows. Two silage-based diets were alternately fed during six three-week periods. The diets differed with regard to the amount of rumen degradable protein (RDP) surplus (in dutch: OEB), but were balanced in their sodium+potassium content to ensure equal urinaty volumes. One diet contained a small RDP surplus (diet L) and resulted in a 39% lower emission rate, compared to a diet which contained a high amount of RDP (diet H). The concentration of urea in the urine samples was 42% lower for diet L compared to diet H. Milk production per cow slowly decreased from 33 kg/day at the start to 27 kg/day at the end of the experiment, with only minor differences between the diets. A decrease in urea concentration as a result of differences in nutrition management could contribute substantially towards diminishing the emission of ammonia from cattle housing systems. Both RDP surplus levels and urine volumes are important in this respect. Further research on this field is in progress.

4. Conclusions

Housing systems with a restricted fouled area, floor systems that prevent the emission from the underlying pit, flushing with water or a formalin solution over slatted floors, acidification of slurry in the pit under the slats, flooding systems in which slats are flooded and nutritional measures significantly reduced the ammonia emission from a cow shed. Which measures are applicable will strongly depend on specific farm circumstances, costs of investments and costs of operating manure handling techniques.

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Solid concrete floor, sloped in a V design 3% to the centre, with a urine drain in the centre.

Optimal use of water, chemicals and energy for cleaning of milking equipment

J.G.P. Verheij (PR-Lelystad)

Abstract

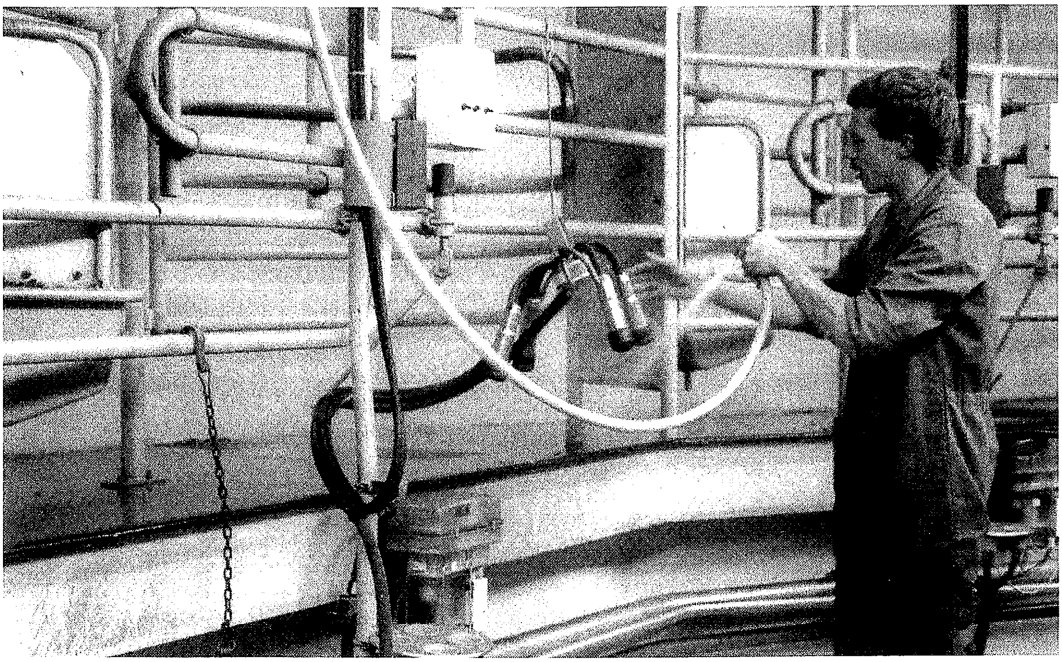
Proper cleaning of milking equipment requires a large quantity of water and produces much waste water. The need for good cleaning is emphasised by EU-Directives concerning heat treated milk and hygiene at dairy farms. National legislation has led to considerable expenses with respect to disposal of effluent. This study aims at reducing these costs and pollution, while maintaining milk quality.

In our research various methods to reduce the volume of water required to clean the milking equipment were investigated. The rsults also indicated that considerable savings in energy consumption and use of chemicals are possible. In all cases the conditions for strict protection of milk quality were evaluated, since new systems should not jeopardize milk quality but rather improve safeguards. At present methods are being developed to reduce the volume of water required for optimal parlour cleaning.

1 Introduction

The cleaning of milking equipment involves three phases: the prerinse, circulation cleaning and postrinse phase. To ensure product quality in a reliable way, the input of water, chemicals and energy has traditionally been rather abundant. Recent legislation has resulted in considerable expenses for disposal of effluents. These restrictions led us to study the optimisation of cleaning in order to define the real minimum requirements for reliable cleaning at minimal costs.

Research reports on this process are sparse. Recent work in the USA and Germany describes model cleaning tests and the proper control of air injection for optimum slug flow.



Circulation cleaning of equipment is studied, but also parlour cleaning efficiency

The usual 'standard cleaning' procedure uses fixed quantities of fresh water for every phase. Combined alkaline cleaning and disinfection agents are commonly used in the main (circulation) cleaning phase. Standard cleaning produces around 10 L of waste water containing milk and chemicals (per cow per day).

Since the largest volume of water is used in rinsing, our first approach was to study rinsing efficiency by monitoring the decrease in the residual concentration as a function of water flow. This helps to define the required amount of water for one cycle. Further opportunities for savings were found in re-using cleaning fluids. A number of procedures have been worked out and tested.

Much emphasis had to be placed on hygienic performance and reliability of each suggested process under practica1 conditions.

Out of a number of topics investigated, two examples are presented in 3

2 Methods

Most of the rinsing experiments were done in a specially designed experimental milk parlour (Figure 1.)

Many practical configurations were possible (bores of pipe, vacuum levels, jars or meters, air injection settings etc.) The basic test method was conductivity monitoring during rinsing (sensor located at milk pump outlet), and to express this parameter as a function of water flow ('rinse curves'). Before each test run a salt solution with the same conductivity as milk was circulated. The rinse curves were fitted into a Genstat model that should cover at least 85% of the measured values, otherwise the results were ignored. The calculated initial value (=100%) was derived from the fitted curve, as well as the average percentage decline per liter water and the water volume needed to reach 99% conductivity reduction.

The effects of rinsing on bacteria numbers in different parts of the installation were studied in addition to the rinsing experiments. After circulating fresh warm milk during 5 minutes the circuit was cleaned (standard process), only prerinsed or not cleaned at all. After 15 hours at 20 C either the milk line or the complete circuit were rinsed with a mixture of sterile milk and tap water (1:6). Before and after circulation this mixture was sampled for total plate count, lactobacilli and coliforms.

Electronic temperature data loggers were used to monitor temperatures simultaneously at various points in a circuit.

During extended practica1 use of any system, the bulk milk was examined weekly for total plate

Figure 1 Schematic view of milk parlour in cleaning position, with lowlevel milk lines and without recorder jars or milk

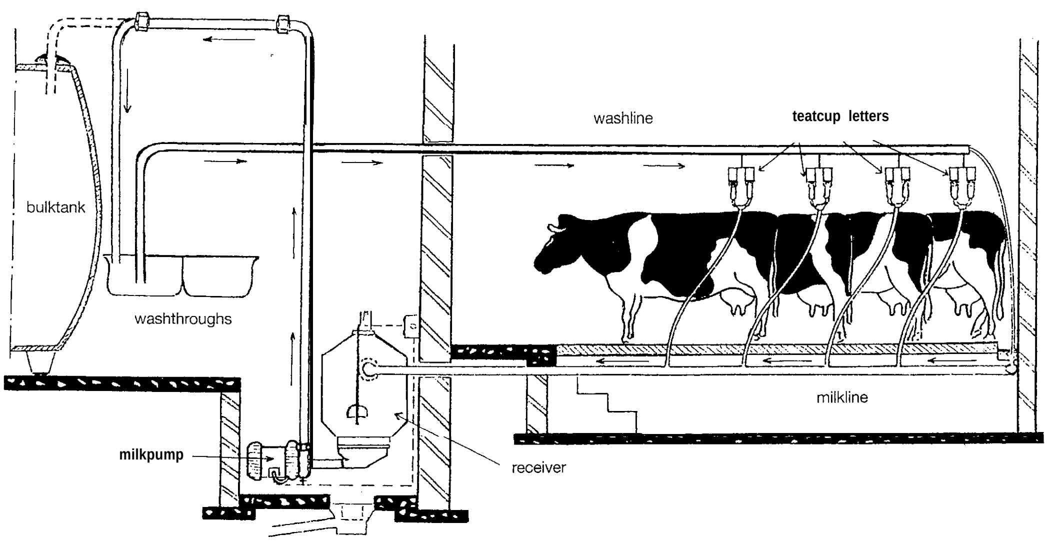


Table 1 Rinse water consumption related to vacuum level and slug volume (milk line bore 50 mm, 2 high rinselines 32 mm)

Slugs (L)	1 x60	2x30	5x12
Vacuum kPa)			
40	37.1	34.2	29.6
50	36.4	31.9	29.9
60	32.2	30.2	32.5
stand. deviation		3.50	

Table 2 Mean logariyhmic bacterial counts (log cfu/ml) of bulk milk in pre- and test period; 10 weekly samplings in each period.

	pre period	test period
Total plate count	3.62	3.44
Thermoduric bacteria	1.45	1.78
Lactobacillaceae	1.45	1.71

count, thermoduric bacteria and Lactobacillae. Thorough visual inspection was also routinely carried out.

3 Results

3.1 *Rinsing efficiency*

For a standard parlour layout Figure 2 presents rinse curves showing the effect of vacuum (significant difference) and of slugs (trend only). The interaction between both effects is demonstrated in Table 1. The vacuum effect decreases as smaller slugs are chosen. From visual observation it was concluded that 12 L slugs were sufficient to provide even distribution over the eight stands.

The inclusion of recorder jars in the installation did not increase water consumption at high vacuum levels. With a 75 mm milk line the effects of both vacuum level and slugs were more pronounced.

The microbial experiments showed that microbial growth in the milk line was limited by cleaning, but that a proper prerinse was equally successful. However, when the clusters were included in the circuit complete cleaning was found to have a significant effect under experimental conditions.

3.2 *Bulk cleaning*

In this case the alkaline cleaning fluid is retained after each use during a week and then discharged and followed by one acid cleaning.

Table 2 shows equal performance for normal and bulk cleaning, except for a slight increase of Thermoduric bacteria. The bulk container must be insulated to prevent heat loss. Daily checks of the composition of the bulk cleaning fluid showed an initial decline of active chlorine which then stabilized at around 120 ppm. The concentration of alkaline detergent and of milk pollution usually remained stable for a week. Bulk cleaning benefits from rapid drainage of liquids between cleaning phases, and especially contamination with milk must be small. Further work will study the extended use of cleaning fluid.

4 Discussion

Safeguarding milk quality was a first priority throughout this work. Experimental evidence was produced for the hygienic vulnerability of clusters, where the rubber surfaces are less sanitary (especially after longer use) and flow of cleaning liquid is restricted. The performance of all new systems was tested in practice during extended use, and satisfactory results were found for a number of processes.

Table 3 summarizes reductions in various aspects of some systems.

In practice a choice must be made within existing restrictions, but combinations of systems can yield profits in some cases.

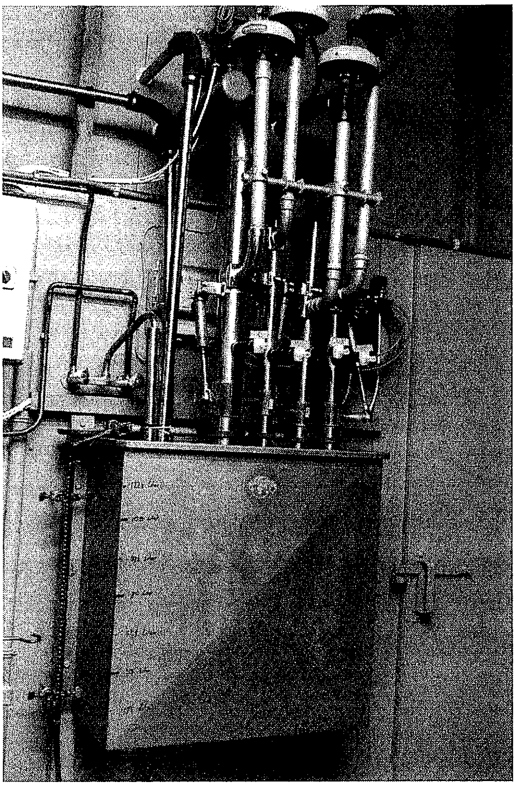
5 Practical application

The experiments produced many arguments for improving design and operation. As an example, significant heat loss is a common feature of existing systems. Many sources of such losses were identified, such as hot water transport, waiting times, defective drainage etc. The need for rapid drainage of the circuit between cleaning cycles was evident. It prevents dilution of the next phase, helps to maintain high temperatures and saves time.

Equipment suppliers have participated in the development of the project and this topic has become a sales item, several suppliers developing new products or features. Demonstration

Table 3 Example of savings of energy, water and chemicals as compared to current standard cleaning

Saving (%) in:	energy	tap water	chemicals
System:			
Standard	0	0	0
Optimised rinsing	17	33	0
Bulk cleaning	30	45	60



Equipment for metering water and air in experimen tal milk parlour

projects on the regional experimental farms have contributed to farmers becoming increasingly interested in the problem and the solutions. Reports were published and the press showed a great deal of interest. A technical seminar with practica1 workers in the field has been planned for late 1995.

The reduction of water consumption in the cleaning of parlours is currently being studied. Fut-ther work on water management on the dairy farm is envisaged.

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Energy use and methods for reduction

Mrs. I.W. Hageman and
F. Mandersloot (PR-Lelystad)

Abstract

The PR research station has recently studied the effect of several management strategies on energy use and farm economics at daity farms. The effects were estimated with the BBPR and ENERGY simulation models. Only about 20% of the total energy use of dairy farms is used for energy carriers such as diesel and electricity. More than half of all energy is used through purchase of concentrates and mineral fertilizers. Farms can save on energy use by increasing the quantity of maize silage in the cattle's diet. Increased milk production per cow and reduction of the number of offspring combined with lower nitrogen fertilization on grassland will save energy as well. Proper tuning of the tractors capacity to the power needs of field work will diminish the quantity of diesel needed.

1 Introduction

In the 1980's energy use was an important issue because of high energy prices. When the prices dropped the attention on energy use declined. Since the Dutch government has set environmental goals to achieve more sustainable daity farming, the use of energy has regained interest. The animal husbandry sector aims for a 30% increase in energy efficiency from 1990 and 2000. PR has studied possibilities to reduce energy use, using the BBPR programme. BBPR computes data on fodder supply, environmental parameters and economics. The ENERGY module that is part of BBPR provides information on the farms' energy use.

The total energy use is derived by multiplying the amount of energy carriers, products and services with their respective energy contents. The energy content includes all energy necessary to produce a specific item. For instance, the energy used for growth of ingredients, transport and manufacturing of concentrates all contributes to the energy content of concentrates. Table 1 shows the energy content of some important products. Energy use consists of both direct and indirect sources. The direct sources are energy carriers such as diesel fuel, electricity and natural gas.

Table 1 Energy contents of some products.

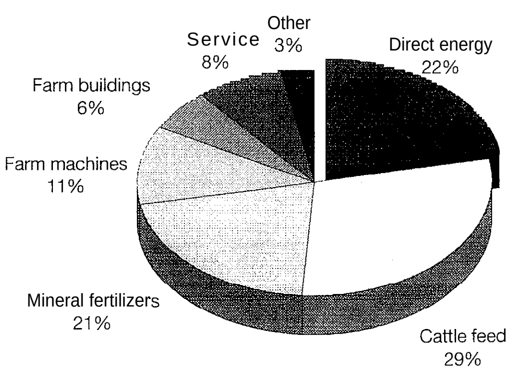
Product or service	Energy content
Diesel fuel	39.6 MJ / l
Electricity	8.7 MJ / kWh
Concentrates	6.4 MJ / kg
Nitrogen fertilizer	38.9 MJ / kg N
Maize silage	0.9 MJ /kg dry matter

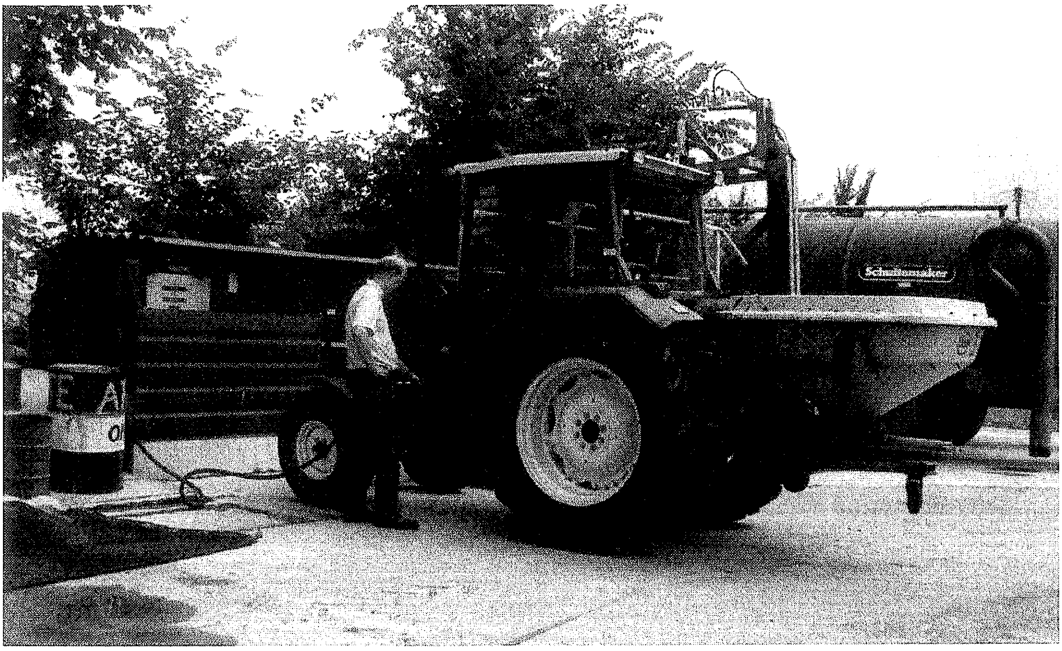
Indirect energy use originates from products and services such as concentrates, mineral fertilizers and contract work.

2 Energy saving strategies

The two PR analyses showed variations in energy use for milk production ranging from 373 to 742 megajoules (MJ) per 100 KGs of milk. Figure 1 shows that only 22% of the total energy use is direct energy. Therefore, direct energy use on dairy farms requires less attention. Indirect energy use consists mainly of cattle feeds and mineral fertilizers. Use of these resources depends strongly on farm management. The energy use of farm buildings, machinery and services is relatively small and hardly varies with the farm set-up. Therefore these items are not discussed in this paper. The next sections show energy saving strategies and their economic consequences.

Figure 1 Energy use at dairy farms





Use of an over-rated tractor will cause a too high diesel consumption.

2.1 *Direct energy*

Factors such as working speed, machine width and power rating of a tractor, influence the diesel consumption. A tractor with excessive power rating will use more diesel than is actually needed for the job. For example for turning 1 hectare of grass silage a tractor of 45 kW will do. This tractor would only use 1.8 litres of diesel per hectare. A 85 kW rated tractor consumes 5.0 litres of diesel for the same job. Diesel consumption at farm level can be reduced to 40% by operating accurately-rated tractors. A heavy-duty tractor is often bought solely for a limited number of power intensive jobs. It is both energetically and economically attractive to let a contract worker perform these tasks.

Electricity and natural gas are mainly used in the milking process. Possibilities for saving on these direct energy sources are indicated in the paper on optimal use of water and chemicals for cleaning milking machines.

2.2 *Indirect energy*

Concentrates

The energy use through concentrates can be reduced by feeding maize silage or concentrate replacements. Another possibility is reducing the number of animals. This can be achieved by a higher milk yield per cow or by reducing the number of offspring per cow.

Maize silage is superior to grass silage in nutritive value. Expansion of the maize silage component of cattle's diet decreases the concentrate intake. This strategy saves 15 to 30% on energy use through concentrates. Relatively high costs for cultivation of maize silage will diminish the farms' gross margin.

The concentrate intake of cows can be reduced by feeding concentrate replacements such as fodder beets and maize cobs. This may cause energy use through concentrates to drop by up to 40%, but will also lead to a lower gross margin. Again, because of higher cultivation costs the gross margin is lower.

When a cow achieves a higher milk yield, it will need more concentrates. Since the total production capacity for each farm is fixed by quota system, the number of cows and offspring will fall at higher yields. Combining these factors leads to reduced concentrate intake and to lower energy use. If milk yield increases from 6000 to 8000 KGs per cow, energy use through concentrates will drop by only 10%. However, this strategy does lead to a raise in gross margin and therefore, is still attractive.

Reduction of the number of offspring per cow is efficient in terms of concentrate use. Energy use

Table 2 Grouping of 84 daity farms based on energy use throughcattle feed and mineral fettilizer per 100 kg milk for 1993/1994.

Group	L(ow)	M(edium)	H(igh)
Milk quota (kg/ ha)	12,871	12,897	13,005
Total acreage (ha)	28.8	27.9	33.0
Acreage maize silage (%)	19	13	10
Milk production (kg / cow)	7293	7230	7027
Concentrate intake (kg / cow incl offspring)	2071	2229	2370
Nitrogen fertilization grassland (kg/ ha)	352	359	408
Offspring per 10 cows	7.1	7.8	8.0
Revenue minus feeding costs (gld / 100 kg milk)	79.22	78.14	76.28
Energy use (MJ/ 100 kg milk)			
- Concentrates	181	198	215
- Silage	3	8	24
- Mineral fettilizer	69	80	98
TOTAL	253	286	337

can drop about 10%. Since costs and revenues will drop simultaneously, the gross margin remains virtually unchanged.

Silage

Increased milk production and fewer offspring per cow cause reduced silage requirements. This will lead to a reduction of energy use through purchase of silage. If the farm is already self-sufficient the surplus of silage increases. If this is combined with a lower nitrogen fet-tilization on grassland the energy use falls by 10%.

Mineral fertilizers

If the use of mineral fertilizers is reduced, energy use per 100 kg of milk will be lower as well. Reduction of fertilizer use can be achieved by following a reduced fertilization scheme on grassland. Another possibility is producing fodder crops with a higher dry matter production per kg nitrogen compared to grassland.

Energy savings through reduction of nitrogen fertilization of grassland can range from 35 to 65%, depending on the extent of the reduction. If grassland receives less nitrogen, both production and nutritive value will drop. Supplementation with extra concentrates will be necessary. If silage production is below self-sufficiency levels, additional silage will need to be acquired as well. The savings in fertilizer costs will not compensate for the excess feeding costs, so the gross margin will decline.

The dry matter production of maize silage at 150 KGs of nitrogen fertilization exceeds grassland production. An increased percentage of maize silage of the total acreage results in lower nitrogen needs, and thus to lower energy use. If land use includes up to 30% of maize silage, the energy use through fertilizers will fall by 15%.

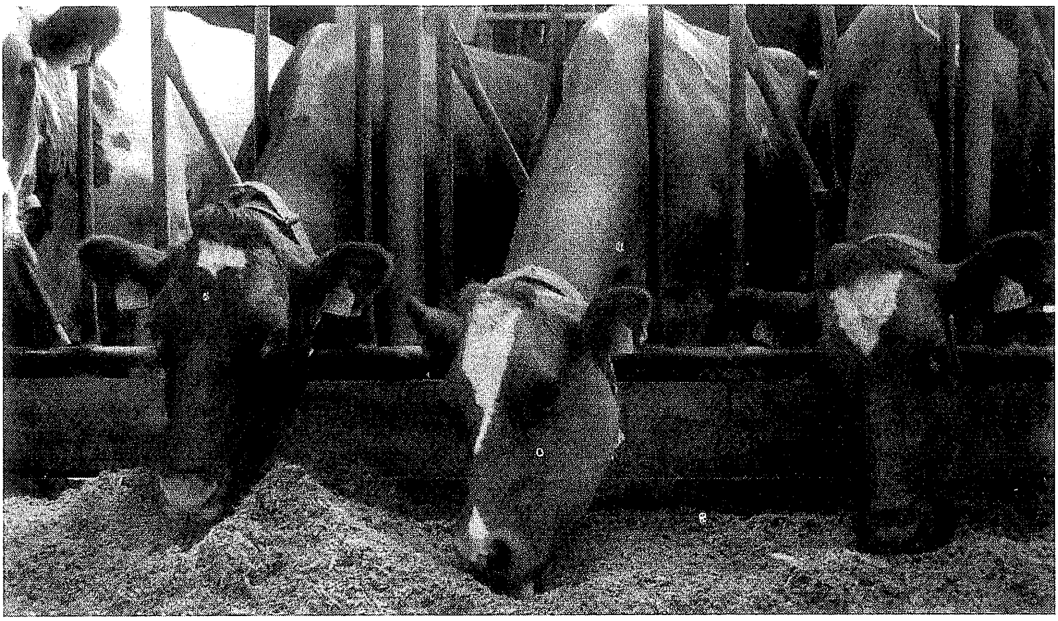
3 Indirect energy use of practical farms

3.1 *Selected farms*

Dutch farmers can participate in a system for technical and economic farm evaluation, called DELAR. The data set for 1994 is used to judge if farmers can actually achieve savings in feed and fertilizer use, as mentioned in the strategies in the previous section of this paper. Farmers recorded data on land use, fertilization, grassland utili-zation, stock size, milk yield and use of concen-trates and silage. The data set contains 825 dairy farms. A group of 84 farmers was selected form this data set. Their milk quota ranged from 12,000 to 14,000 KGs of milk per hectare, and the average milk yield ranged from 6,000 to 8,000 KGs per cow. Next, this group was divided into three categories (low, medium and high), according to the energy use in fertilizers and feeds per 100 kg of milk. Table 2 shows farm data of these three groups.

3.2 *Results*

Both groups M and H have more offspring per cow. They also grow less maize silage. Although the use of nitrogen fertilizer on grassland in groups L and M is equal, group L uses less nitrogen per 100 KGs of milk. This is because of the larger percentage of maize silage in total land use. Group H uses most nitrogen fertilizer per hectare grassland and is lowest in milk pro-duction. High revenues in groups M and H do not compensate for their high feeding costs, so their gross margin is below the margin in group L.



Increasing maize silage in the ration can reduce energy use by 30 %.

Groups M and H can save on concentrates by reducing the number of offspring per cow. An increased acreage of maize silage could reduce their energy use of silage and fertilizer. Group H can reduce indirect energy use even further, through a combination of increased milk yield and decreased nitrogen fertilization.
The disparity in feeds and fertilizer use at equal stocking rates shows that farmers have opportunities for reducing energy use through management changes.

4 Practical application

Correct matching of tractor rating with power needs for field work prevents excessive consumption of direct energy. Short-term strategies for diminishing indirect energy use are reduction of the number of offspring per cow, and expansion of silage production per kg of nitrogen fertilizer. This can be achieved by an increased use of nitrogen efficient maize crops.
On the long run, a raise in milk yield per cow and thus reduction in the number of cows can lead to reduction of energy use. Consequently, because of reduced roughage need the nitrogen fertilization can decrease. This reduces energy use even fut-ther.

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Reduction of nitrogen and phosphorus surpluses

F. Mandersloot, R. Schreuder and
A.T.J. van Scheppingen (PR-Lelystad)

Abstract-

Dutch dairy farmers are adapting their farming system in order to meet environmental goals. The effects of different strategies for reducing nutrient surpluses were calculated with the computer program MINFLOW.

Compulsory strategies, changes in management and use of reduced emission housing systems decrease nitrogen losses. Reduced emission slurry application methods diminish ammonia volatilization considerably. Changes in management affect both ammonia volatilization and nitrate leaching. Reduction of the phosphorus content in concentrates diminishes phosphorous excretion by cattle. Reducing phosphorus fertilization is expected to result in lower dry matter production on grassland.

1 Introduction

Dutch farmers face a growing public concern about the environmental implications of their farming systems. Special attention needs to be paid to losses of nitrogen through ammonia volatilization and nitrate leaching, and losses of phosphorous through leaching. The Dutch government's policy is geared towards the reduction of these losses. The use of slurry storage covers and reduced emission slurry application methods are compulsory. Legislation restricts the quantities of slurry per hectare and the season of application.

Other chapters in these proceedings show several options for reducing mineral losses. This section compares the effectiveness of these options. The most suitable solutions can be selected when the economic implications are clear. The paper of A. van Scheppingen shows the economic consequences of strategies for reducing nutrient losses.

2 Nutrient surpluses at dairy farms

The definition of a nutrient surplus is: The difference between input and output of the nutrient to and from a farm. Table 1 shows nutrient surpluses at different groups of farms. The surpluses tend to decrease during the given period of time. Surpluses from a sample of all Dutch farms are highest. On experimental farms they are lowest. The nutrient surpluses at pilot farms on sustainable dairy farming are in between.

3 Calculation of nutrient flows at dairy farms

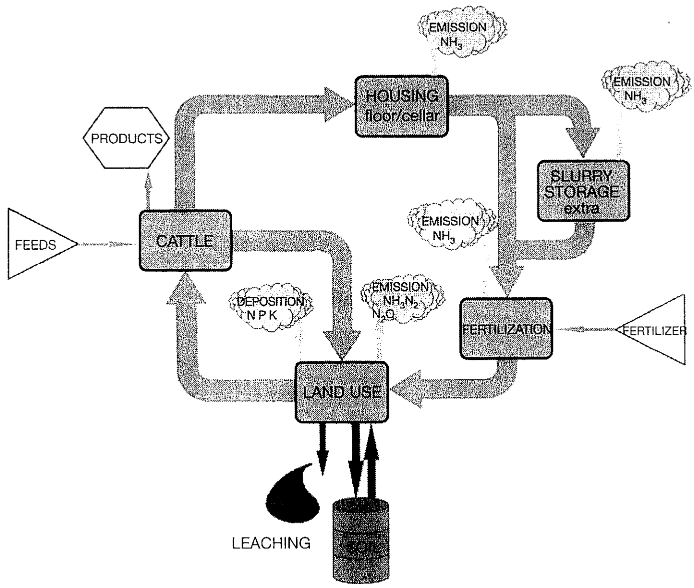
Losses of nutrients cause nutrient surpluses. The

Table 1 Nutrient surplus (kg N and P per hectare) in different years.

	Year			
	1989190	1990/91	1991/92	1992/93
N				
Average farms [1)]	429	401	399	388
Pilot farms [2)]	411	356	321	318
Experimental farms [3)]	341	235	250	270
P				
Average farms	32	30	29	25
Pilot farms	27	25	20	23
Experimental farms	33	19	15	16

[1)] Representative random sample of about 350 dairy farms, Agricultural Economics Research Institute (LEI-DLO)
[2)] Pilot farms on sustainable dairy farming; based on data from about 13 dairy farms
[3)] Research farms for applied research; based on data of about 8 daity farms

Figure 1 Structure of the MINFLOW module.



PR has developed a computer programme (MINFLOW) to monitor nutrient flow in a dairy farm. Figure 1 shows the basic concept of MINFLOW.

In MINFLOW the production process at the dairy farm is split into 5 sections.

- **Cattle**
  Intake of roughage and concentrates implies intake of nutrients. Part of these nutrients are used for milk and beef production. The remainder are discharged in faeces and urine.
- **Housing**
  Excretion of faeces and urine cause volatilization of ammonia from the floor and out of the cellars beneath slatted floors.
- **Slurty storage**
  Storage of slurry in silos outside the cattle house also causes ammonia volatilization.
- **Fertilization**
  Application of slurry causes volatilization of ammonia. Artificial fertilizer is used to supplement slurty in order to meet the nutrients' requirements of crops. Agricultural recommendations and legislative restrictions determine the quantities of fertilizer. Alternatively, fertilization can be balanced with crop removal, taking unavoidable losses into account.
- **Land use**
  During grazing, cattle discharge nutrients. Nitrogen is lost by volatilization of ammonia, leaching of nitrate and accumulation in the soil. Phosphorus is lost by leaching or can accumulate in the soil.

4 Nitrogen losses

Strategies for reducing nitrogen losses at dairy farms can be divided into three groups:

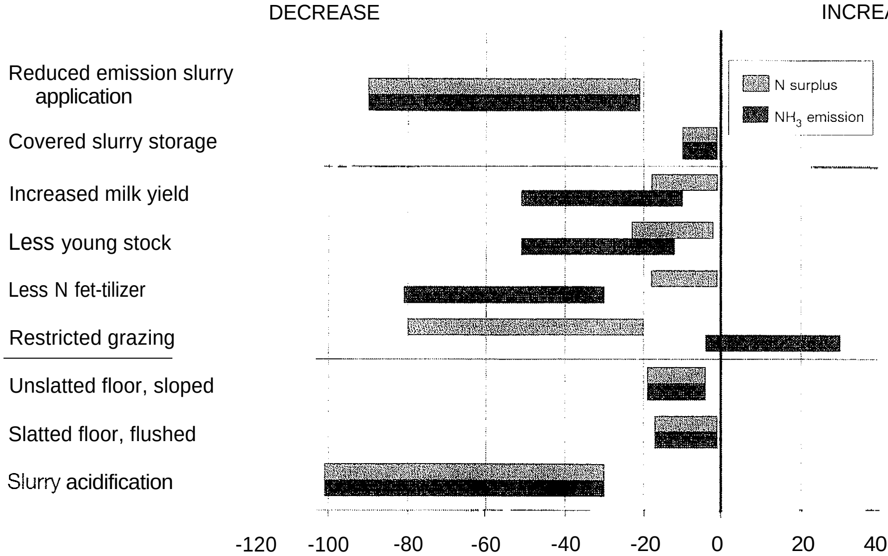
- Compulsory strategies
- Management changes
- Reduced emission housing systems

Figure 2 shows reduction of nitrogen and ammonia losses for a range of strategies. Different strategies can interact with each other. Therefore results can not be added up to determine an overall effect.

4.1 Compulsory s trategies

In order to reduce ammonia volatilization, farmers are forced by law to use reduced emission slurty application techniques and to cover slurry storage silos. The reduction of the nitrogen surplus by reduced emission slurry application ranges from 20 to 90 kg per hectare. This variation is mainly caused by differences in stocking rate. Farms with a high stocking rate produce more slurry than farms with a lower stocking rate. Therefore the reduction in ammonia volatilization and nitrogen surplus is more marked. The reduction of nitrogen surplus

Figure 2 Change in nitrogen surplus and ammonia emmision under different strategies in order to reduce losses.



by covering slurry storage silos is much smaller.

4.2 *Management changes*

Farmers can adjust their management in order to reduce nitrogen losses. Figure 2 shows that this group of strategies causes a larger decrease in nitrogen surplus than the decrease in ammonia volatilization alone. Therefore, other nitrogen losses, particularly leaching of nitrate, are reduced as well.

An increase in milk yield at the same milk quota level will lead to a decrease in the number of animals and thus to less nitrogen loss. A decrease in the number of followers has a similar effect. A reduced nitrogen fet-tilization level on grassland contributes to a lower nitrogen input. The impact on nitrate leaching is significantly bigger than on ammonia volatilization. In restricted grazing, dairy cows stay indoors during the night. This reduces the number of urine patches in grassland. Consequently, nitrate leaching decreases considerably. Since more slurry must be stored, ammonia volatilization tends to increase. The overall result is that nitrogen surplus goes down.

4.3 *Reduced emission housing systems*

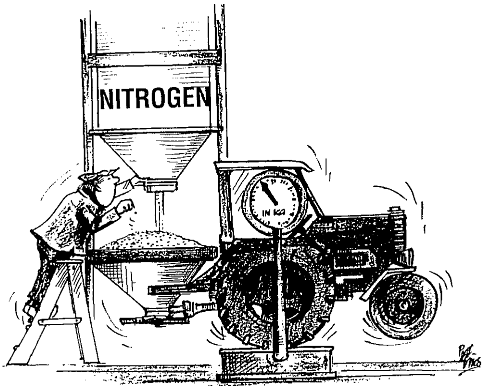
Nitrogen can only be lost from cattle housing through ammonia volatilization. Adaptations to housing such as a sloped unslatted floor and flushing a slatted floor, reduce these losses. Compared to other strategies the reduction of the nitrogen surplus is rather limited. Another option for decreasing nitrogen losses is acidification of slurry. Addition of nitric acid to slurty reduces ammonia volatilization from the cellars and in storage silos as well as after application. For that reason, acidification has such an impact on nitrogen loss. The paper of van Scheppingen presents detailed information on this topic.

5 Phosphorus losses

Dutch fertilization recommendations aim for a constant level of readily available phosphorus in the soil. If the level is too low, recommendations exceed crop requirements. Due to the extensive use of concentrates, slurry contains more phosphorus then is necessat-y for fertilization purposes. This leads to phosphorus accumulation in the soil, and eventually to leaching. Therefore, legislation limits the application of slurty. In 1995, application of quantities exceeding 150 kg of phosphate (65 kg phosphorus) per hectare grassland is prohibited. Legislation does allow for supplementation with artificial fertilizers to meet recommendations.

5.1 *Less phosphorus in concentrates*

Phosphorus enters the farm mainly in concentrates. Generally, the phosphorus level in concentrates exceeds cattle requirements. Calculations indicate possible reduction of phosphorus excretion by at least $1\frac{1}{2}$ to $2\frac{1}{2}$ kg P per cow per year. At present, legislation does not



Reduced nitrogen fertilization: less ammonia volatilization and nitrate leaching.

allow use of farm specific data on phosphorus content of slurry. If this changed, a reduction of the phosphorus levels in concentrates would lessen the need for slurry removal from the farm.

5.2 *Reduced phosphorus fertiliza tion*

As mentioned before, a certain phosphorus surplus is needed to keep the phosphorus level in soil at an optimum. Field trials indicate this surplus should extent to about 20 kg phosphorus per hectare. If future legislation aims at lower surpluses, the fertilization level must be reduced. This results in an estimated 0% to 14% drop in fodder production. If the phosphorus surplus has to be reduced to zero, dry matter production of grassland may drop even further.

6 Adoption of strategies

Some strategies for reducing nitrogen losses have been successfully adopted by daity farms. Reduced emission slurry application techniques were widely practised within a few years following introduction. The covering of slurry storages is widely spread as well. This is partly due to legislation.

In the Netherlands the average milk yield per cow increases each year. Since the national milk quota has not changed, the number of cows has dropped significantly. The number of 11 young stock has decreased accordingly. The drop in the number of animals has resulted in a reduction of nutrient surpluses. Besides that, feed production can decrease. This allows for a reduction in nitrogen fet-tilization. Concentrate manufacturers have released concentrates with a standard low level of phosphorus in order to reduce the phosphorus excretion of dairy cattle. They are now developing new concentrates with even lower levels of phosphorus.

All these strategies have an impact on nutrient losses. However, they also influence the farmer s income. The next paper focuses on this point.

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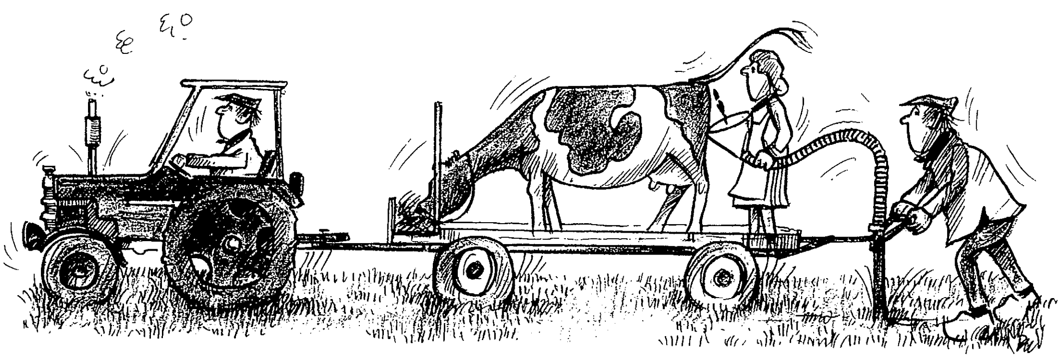

Reduced emission slurry application: effective strategy

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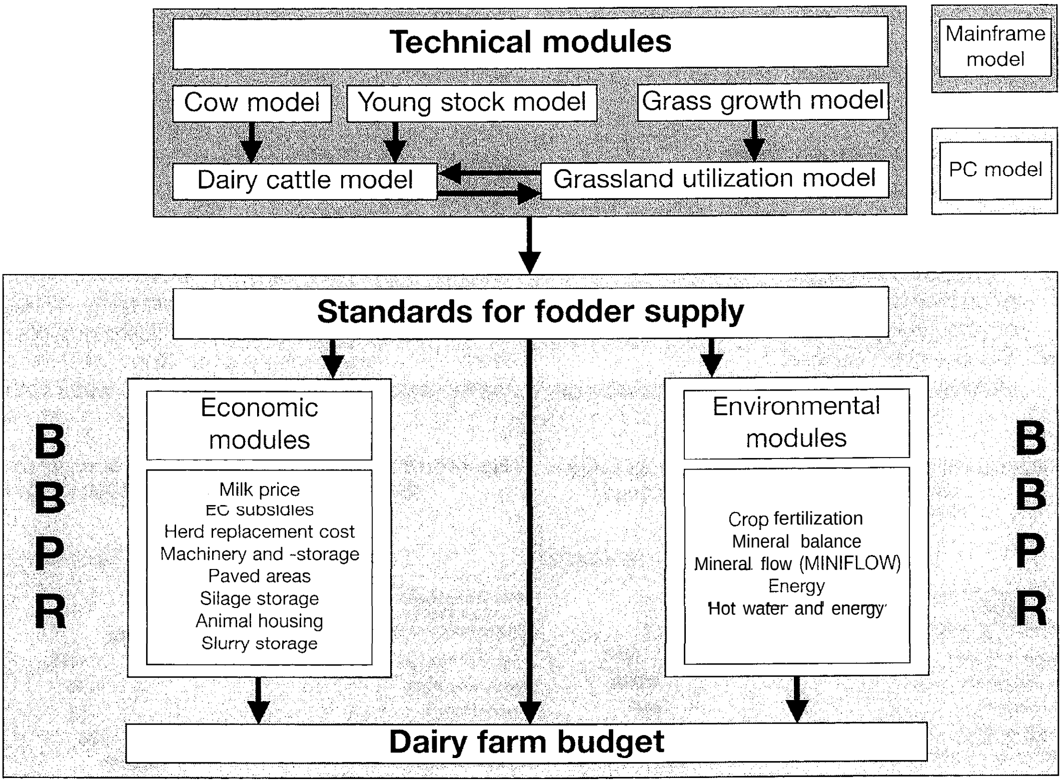
Economic effects of strategies to reduce nitrogen and phosphorus surpluses

A.T.J. van Scheppingen, S.J.F. Antuma and F. Mandersloot (PR-Lelystad)

Abstract

The adoption of strategies to reduce nitrogen and phosphorus surpluses influence the farmer s income. The computer model BBPR has been used to determine this change in income.
The most cost effective strategies for reduction of the nitrogen surplus are management changes such as: increased milk yield, reduced nitrogen fertilization level on grassland and reduced emission slurry application. The compulsoty coverage of slurry storage is less cost effective. Reduced emission housing systems like slurry acidification, the sloped unslatted floor and especially flushing a slatted floor are least cost effective. Therefore this line of research needs further development.
At his moment legislation does not support farm specific data on phosphorus levels in slurry. Reduction of the phosphorus content of concentrates requires extra costs but can still be an economically viable option, if use of farm specific data is authorised. The effects of reduction of phosphorus fettilisation are still under investigation.

Figure 1 Structure of BBPR and its modules



1 Introduction

A healthy dairy sector is vital for Dutch economy. This sector contributes about 40 percent to the national trade surplus. This has to be considered when defining environmental policy. There are many strategies for reducing mineral surpluses. Some strategies, including their technical results were mentioned in the previous paper. This paper shows the financial impact of those strategies.

2 BBPR, a tool for farm economic research

PR has developed the daity farm budgeting programme BBPR to determine technical, economic and environmental effects of changes in farm management. The structure of BBPR and its modules is shown in Figure 1. There are major components for calculating fodder supply, for economic information and environmental assessment. These parts are all combined in the farm budgeting programme. The modules are linked and can use each other 's results. Besides that, the modules can run separately to tackle individual problems. BBPR is used in evaluations, as in this paper, and for planning purposes for informing farmers. The economic effects of strategies for reducing nutrient surpluses in this chapter were calculated with BBPR by comparing different situations.

3 Reduction of nitrogen losses

In the previous paper strategies for reducing nitrogen losses at dairy farms were divided into three groups:

- Compulsory strategies:
  Reduced emission slurry application and covered slurry storage;
- Management changes:
  Increased milk yield, less young stock per cow, reduced nitrogen fertilization and restricted grazing;
- Reduced emission housing systems:
  Sloped unslatted floor, flushed slatted floor and acidified slurry.

3.1 Economic effects

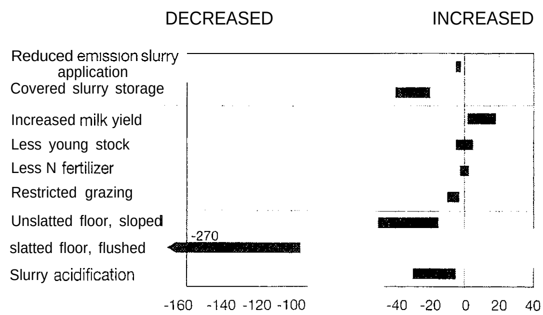
Figure 2a shows the economic effects per hectare of each of these strategies. The compulsory strategies have a relatively small effect on farm income. Both techniques in this group decrease farm income by up to 100 guilders per hectare. They lead to an increased nitrogen recovery from manure and so to a reduction of fertilizer costs. This almost completely compensates for the extra costs of these strategies.

An increase in milk yield always leads to better economic results. The effects of reducing young stock and reducing the nitrogen fettilization levels differ between two groups of farms. If farms are more than self-sufficient in silage production, economic results improve. However, if silage must be bought to compensate for the reduction in young stock or fertilization, the effect on farm income is negative. In restricted grazing, animals stay inside during the night and are fed with additional roughage. When compared to unrestricted grazing, the costs of restricted grazing range from 50 to 250 guilders per hectare. This is due to extra costs for fodder harvesting and manure application. In unrestricted grazing, the animals petform these tasks themselves.

Adaptations to housing in order to prevent nitrogen losses are relatively expensive. Moreover, they require long term investments, which reduce liquidity. The process of flushing a floor leads to a larger amount of slurty (including waste water). Costs for equipment, water and

Figure 2a Change in income (guilders / hectare) under different strategies for reducing nitrogen losses.

Figure 2b Change in income (guilders / kg N) under different strategies for reducing nitrogen losses.



extra slurry applications range from 400 to 1600 guilders per hectare, depending on stocking rate. Construction of a sloped unslatted floor results in extra annual costs, ranging from 100 to 450 guilders per hectare. Nitric acid, which is used for acidification of slurry, contains nitrogen. If the nitrogen fet-tilization with acidified slurry reaches the recommended levels, the remainder of the slurry is removed from the farm, at a cost of 15 guilders per cubic meter. This corresponds to costs ranging from 200 to 1600 guilders per hectare, depending on stocking rate.

3.2 Cosf *effectiveness*

The combination of the technical and economic effects of each strategy on reducing nutrient surpluses determines the cost effectiveness. The cost effectiveness is the change in income per kg reduction of nutrient surplus. Figure 2b shows the cost effectiveness of each of the surplus reduction strategies. Management changes and reduced emission slurry application are far more effective than changes in the housing system. The costs of management changes and reduced emission slurry application are below 10 guilders per kg nitrogen surplus reduction. Slurty storage covering costs range from 20 to 40 guilders per kg nitrogen surplus reduction. For housing adaptations the costs may even go up to 50 guilders per kg. The system for flushing a slatted floor is the least cost effective. With this system it takes up to 270 guilders to reduce the nitrogen surplus by only one kg.

4 **Reduction of phosphorus losses**

At his moment legislation does not support farm specific data on phosphorus levels in manure. The rest of this section on phosphorus shows what would happen if legislation allowed for use of farm specific data.

4.1 *Less phosphorus in concentrates*

The phosphorus surplus can be reduced by a decreased level of phosphorus in concentrates. If this requires ingredients that are more expensive, concentrate prices will increase. The reduced phosphorus level in slurry would allow the farmer to use more slurry on his own land. This would save expenditure on manure removal. Table 1 indicates the permitted price increase at different slurry removal costs. At these additional costs, on top of the default 33 guilders per 100 KGs, the farmer 's income will remain unchanged. For a dairy system based solely on grassland, the low-P concentrates may cost from 0.33 to 2.63 guilders per 100 KGs extra without causing a drop in the farmer s income. On a dairy farm that grows maize silage on 30 % of its land, feeding

Covering manure storage: compulsoty strategy, but very expensive per kg nitrogen surplus.

Table 1 Maximum permitted price increase for low-P concentrates, at different levels of slurry removal costs and land use systems, in guilders/1 00 KGs and in % of default concentrate price of 33 guilders/100 KGs.

Land use	Slurry removal costs (guilders per m^3)		
	15	20	25
100% grass	0.33 (0.10 %)	1.48 (0.45%)	2.63 (0.80 %)
70% grass -- 30% maize	0.06 (0.02 %)	0.94 (0.28 %)	1.81 (0.55%)

low-P concentrates will be less attractive. The diet of silage, including maize, is low in phosphorus already. Hence, the reduction in manure removal is much smaller. The permitted additional concentrate costs range from only 0.06 to 1.81 guilders per 100 KGs on top of the default 33 guilders per 100 KGs.

4.2 *Reduced phosphorus fertilization*

The previous paper shows that reduction in phosphorus fertilization will lead to a lower phosphorus surplus. It will provoke another chain of reactions as well. Research indicates that both grassland production and phosphorus content of grass may drop. As a result slurry will have a lower phosphorus content. If the drop in grassland production induces a silage deficit, extra feed will enter the farm. These products will influence slurry phosphorus levels as well. If legislation allows for use of farm specific data on phosphorus levels in slurty this may influence slurry removal quantities. These relationships are all catered for in BBPR and MINFLOW. PR has recently started research in this field to quantify both technical and economic effects.

In an example calculation the phosphorus surplus was reduced from 40 to 5 KGs per hectare by removing excess slurry. Grassland production was set at 9% below normal. The farm has 20 hectares of pasture and grows 5 hectares of maize silage. Milk quotum is 12.000 kg per hectare, and milk yield is set at 7500 KGs per cow. The reduction in phosphorus fet-tilization resulted in a drop in income of 125 guilders per hectare. If slurry removal costs rose from 15 to 25 guilders per m^3, income would decrease by 140 guilders per hectare.

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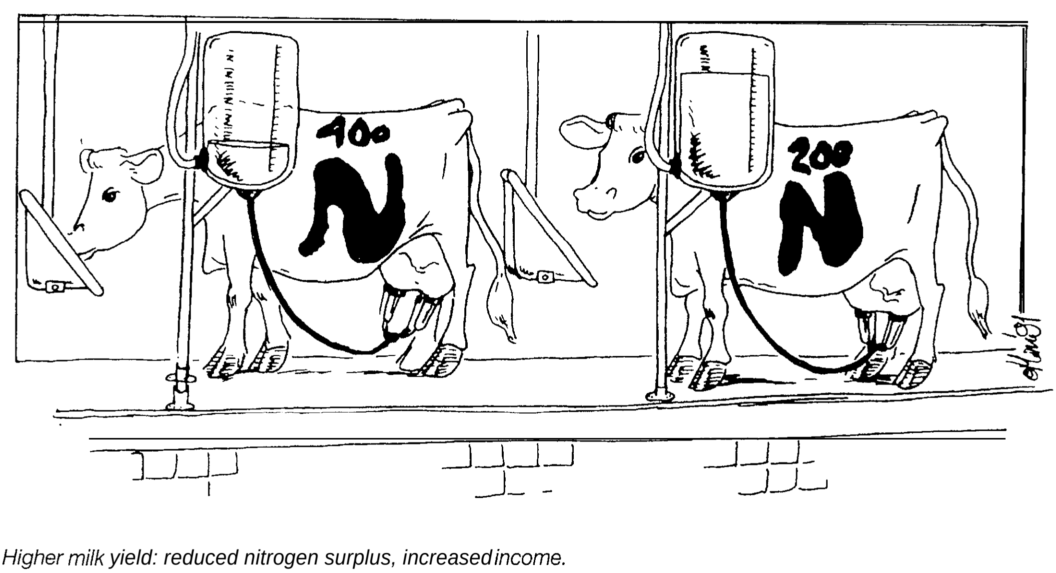

Higher milk yield: reduced nitrogen surplus, increased income.

income by keeping more young stock at dairy farms. Report 144 (in dutch; summary and list of tables, figures and appendices in english). Research station for cattle, sheep and horse husbandty (PR) Lelystad.

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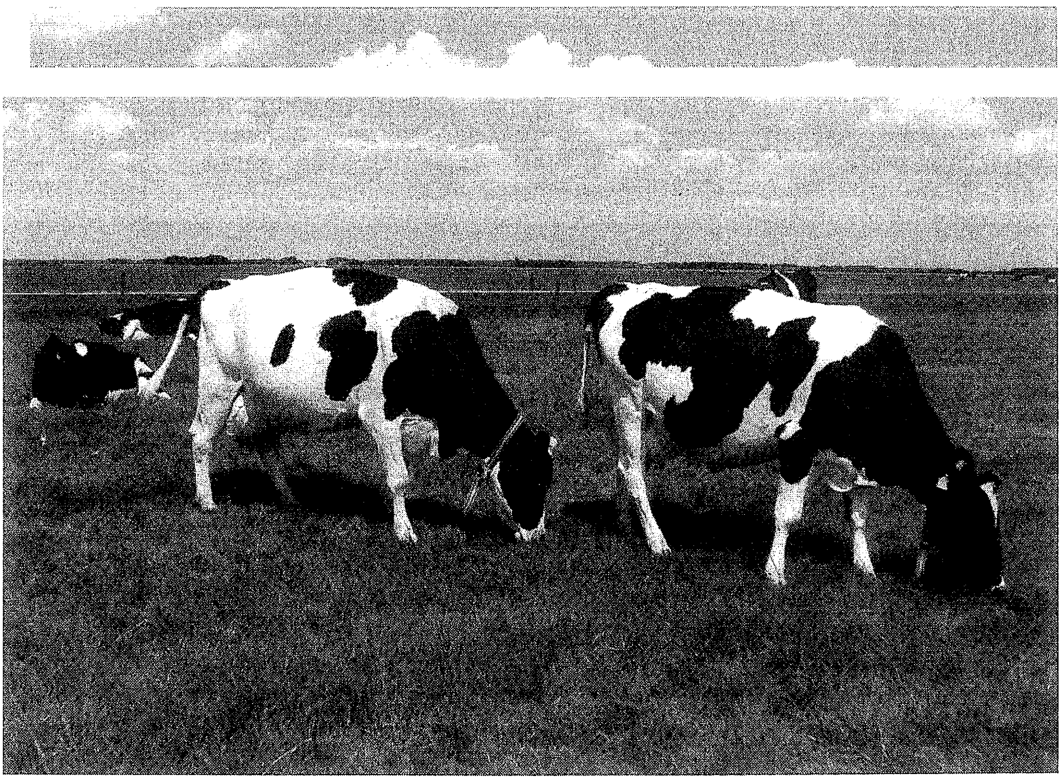


New opportunities for perennial ryegrass-white clover mixtures

R.L.M. Schils (PR-Lelystad)

Abstract

The introduction of milk quota and an increasing concern about nutrient losses in daity production systems have led to renewed interest in white clover in the Netherlands. Results of cutting trials on clay and sand showed the beneficial effect of spring nitrogen on dry matter yields without depressing clover content too much. Results of a farm scale comparison between grass/nitrogen and grass/clover swards are presented. They demonstrate the technical performance of white clover in dairy husbandry, taking into consideration herbage production and quality and animal production. Although gross margins per cow were slightly higher for grass/clover, the higher stocking rate on grass/nitrogen resulted in higher margins per ha for the latter. The nitrogen balance showed a shift from an input through fertilizer to input through biological fixation, but the nitrogen utilization did not improve. Clover content was very irregular between years, seasons and paddocks. Improvements in the system in order to tackle the problems related to this irregularity are discussed.

1 Introduction

The introduction of milk quota and an increasing concern about nutrient losses in dairy production systems have led to a reduction in nitrogen input and consequently to renewed interest in white clover in the Netherlands. A fut-ther reduction in stocking rate may be expected in the near future, increasing the scope for white clover. To evaluate the possibilities of white clover a research programme was started in 1989, consisting of some detailed cutting trials and the development of a white clover based dairy system. In this article results of trials on strategic nitrogen application are presented as well as the results of the white clover based dairy system. The article concludes with an ovetview of present research with mixed swards at our research station.

A grass/clover mixture being cut for silage

Table 1 Effect of spring nitrogen (kg/ha) on dry matter yield (kg/ha), nitrogen yield (kg/ha) and white clover content (%)

Nitrogen	First cut	Whole year		
	DM Yield	White clover	DM Yield	N Yield
Clay (1989- 1993)				
0	3266	50	14246	492
50	3811	46	14809	503
100	4235	39	14966	498
Sand (1992- 1994)				
0	*2760*	*42*	13349	*446*
50	*3459*	*36*	*13826*	*450*
100	*3867*	*32*	14090	459

2 Strategic nitrogen application

In Dutch dairy husbandry the spring growth of grass is very important in order to secure a considerable proportion of winter feed and to have grass available for early grazing. Acceptance and adoption by farmers of a system based on mixed swards will depend on its ability to produce enough spring herbage. Although there are good prospects for breeding varieties with improved spring growth, at present it seems sensible to increase spring growth with a strategic nitrogen application. Table 1 shows some results of cutting trials on sand and clay soil. In the first cut the dry matter response to nitrogen was approximately 10 kg DM per kg N. Nitrogen application clearly reduced white clover content, but levels were still very acceptable. Dry matter production after the first cut was slightly lower on fet-tilized plots but at the end of the year a respons of 7 kg DM per kg N was left.

Table 2 Herbage production and silage quality of grass/nitrogen and grass/clover based swards

	Grass/Nitrogen	Grass/Clover
Herbage production		
Nitrogen[1] (kg/ha)	275	69
Grazing days (LU/ha)	432	378
Silage Yield (t DM/ha)	5.7	5.6
Silage quality		
Dry Matter (g/kg product)	434	434
Crude Protein (g/kg DM)	168	179
VEM (/kg DM)	850	859
DVE[2] (g/kg DM)	65	67
OEB[3] (g/kg DM)	43	54

1 Including effective nitrogen from injected slurry
2 Available protein in the intestines
3 Rumen digestible protein balance

3 Comparison of a grass/nitrogen and grass/-white clover dairy system

From 1988 to 1990 mixed swards were established on the experimental farm Waiboerhoeve at Lelystad. Its soil is young marine clay, with a pH around 7, naturally low in phosphate and high in potassium. From 1990 to 1993 a comparison was conducted between a grass/nitrogen and grass/white clover system. The dry matter yield per ha in the grass/clover system was expected to be 15-20 % lower than in the grass/nitrogen system. As the systems had to be self-supporting in silage and there were 60 cows in both systems, 34 and 41 ha were allocated to the grass/nitrogen and grass/clover system respectively.

3.1 *Herbage production*

A rotational grazing system was used for both herds. On average a paddock was grazed for two days by daity cows followed by another two days for young stock and dry cows. The first priority was the availability of grass for grazing and surplus grass was cut for silage. Table 2 shows some results on herbage production. The difference in grazing days per ha is mainly a reflection of the difference in stocking rates. During the summer of 1990 and 1991 the daity cows in the grass system had to be supplemented with silage to overcome drought periods. White clover growth was affected less severely, so there was no need for supplementation.

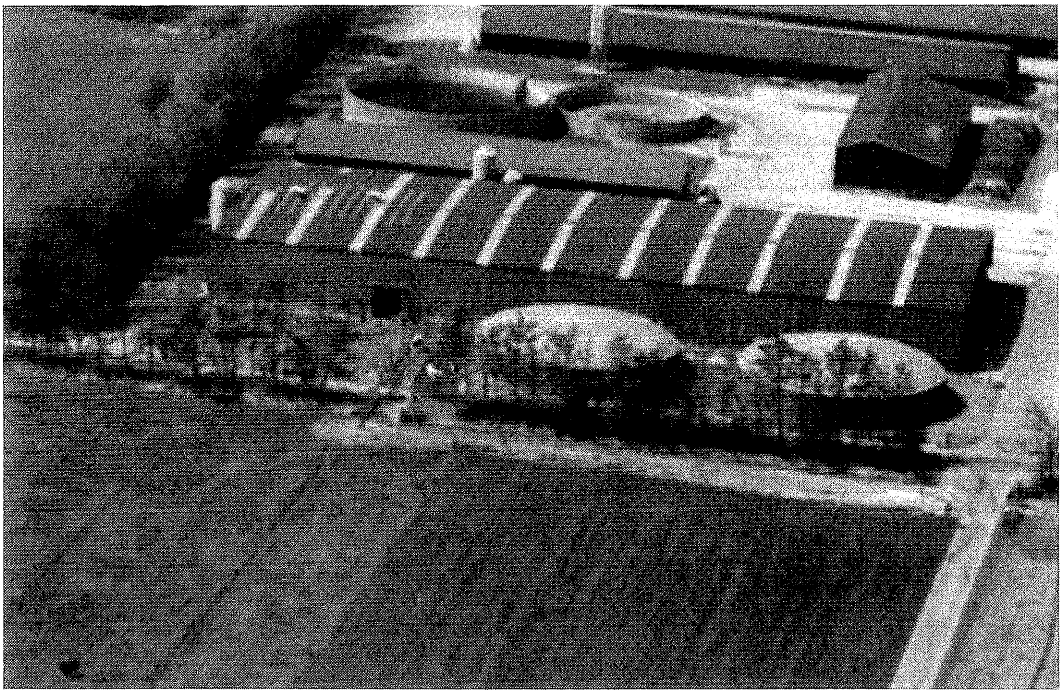
Silage yields per ha were similar in both systems, but with respect to the areas of both systems they were relatively higher on the mixed swards. Compared to the predicted dry matter yields at the start of the experiment, the yield of grass/-nitrogen swards was lower than expected, whe-

Table 3 Milk production and gross margin of grass/nitrogen and grass/clover based dairy systems

	Grass/Nitrogen	Grass/Clover
Milk production		
Concentrates (kg/cow)	1828	1847
Milk (kg/cow)	7608	7746
Fat (%)	4.48	4.54
Protein (%)	3.46	3.45
Gross margin (Dfl)		
Per cow	5349	5487
Per ha	9203	7925

reas the yield of grass/clover swards exceeded the expectations. These differences between expected and realized yields resulted in an average silage shortage of 12 ton DM per year in the grass system and an average silage surplus of 29 ton DM per year in the clover system.
Silage cuts were made at yields of two to three ton DM per ha. Silage quality was almost similar in both systems. Nitrogen content (CP, DVE and OEB) of grass/clover silages made in August and September tended to be higher than those of grass-only silages. Values of net energy for lactation (VEM) showed no major differences.

3.2 *Animal production and gross margin*
Concentrate levels per cow per year were deliberately maintained at similar levels. However, within a year variations occured due to differences in calving patterns. Although the herds had a similar calving pattern (October - April) at the start, unequal shifts in calving patterns were introduced by randomly variable insemination results. Average milk production and fat contents (Table 3) were slightly higher in the clover based system. However, influences such as those mentioned above, may affect the comparison. Analyses of the standard milk production (corrected for lactation stage) showed a higher milk production on mixed swards in the second half of the grazing season. But this was somewhat compensated for by a lower winter milk production from grass/clover silage.
Gross margins are presented in table 3 as well. In the first two years concentrate costs were higher for the grass/clover herd because Poloxalene was added for bloat prevention. In the final year normal concentrate was fed during the grazing period, but as a consequence two cows died of bloat. Fertilizer costs were clearly lower in the clover system. Although the gross margin per cow was higher in the clover system, the lower



Aerial view of the unit in which the system comparison took place. The paddocks are situated to the right and below the farm buildings.

Table 4 Nitrogen balance (kg N per ha) of grass/nitrogen and grass/clover based dairy systems

	Grass/Nitrogen	Grass/Clover
output	80	67
Input	333	279
- concentrates	76	65
- fertilizer	208	16
- fixation	4	180
- silage	9	-18
- miscellaneous	36	36
Surplus	253	212

stocking rate had a major impact and caused a lower gross margin per ha.

3.3 *Nitrogen balance*

Nitrogen fixation by white clover was estimated in the following way. First a total dry matter yield per ha was calculated from the silage yield and the number of grazing days. Combining these yields with the botanica1 composition led to an annual clover yield. With the assumption that each ton of clover (DM) is equivalent to a nitrogen fixation of 50 kg per ha, the total fixation was estimated. Table 4 shows the average nitrogen balance for both systems. Differences in milk and meat output and in concentrate input are a direct consequence of the different stocking rates. The higher intensity of the grass system results into a higher nitrogen surplus per ha. Conclusions are very hard to draw due to the uncertainty surrounding the exact level of nitrogen fixation. However, the high level of estimated nitrogen fixation in this balance is strengthened by measurements of nitrate concentations in drain water. On a selection of paddocks from both systems the average nitrate losses through drain water were 20 and 24 kg N per ha for grass/nitrogen and grass/clover respectively.

4 **Present research**

4.1 *Field trials*

At present a cutting trial is in progress in which the effect of phosphate on mixed swards is studied. Future government policies will restrict the phosphorus input on dairy farms. The question is whether sub-optimal phosphate fertilization will negatively affect the persistency of white clover and consequently the dry matter yield.

Other trials involve the development of suitable sod-seeding techniques to introduce white clover in existing grass swards. Management effects on mixed swards are being studied in a trial on sandy soil in which combinations of strategic nitrogen applications, cutting frequencies and stubble height are being varied.

4.2 *System development*

Although the comparison with grass/nitrogen was not continued, the existing grass/clover system is still involved in futther development. Most remaining questions are directly or indirectly related to the irregularity in white clover content. Although the clover content averaged over all years, seasons and paddocks was at a satisfactorily level of around 35 %, the variation from nearly nil to more than 70 % posed a few problems. Especially the high clover contents were troublesome with respect to nitrate leaching, bloat and poaching risks. A major change that took place in order to tackle these problems was the introduction in 1994 of four ha of forage maize. From July onwards, when clover contents were steadily rising, two to three kg DM of maize silage have been supplemented to the cows. This should reduce the N surplus in the diet and reduce the bloat risk. Moreover management strategies are being developed to try to regulate the clover content within certain ranges. This involves close monitoring of botanica1 composition and frequencies of absence, followed by decisions to cut or graze with a certain frequency or even to re-introduce new grass or clover seeds into a sward.

Besides a dairy system, a new, low input sheep system is being developed on clover based swards. An area of 10 ha is being used to graze 180 ewes plus offspring. No fertilizer or concentrates are being used and labour inputs are being minimized as well.

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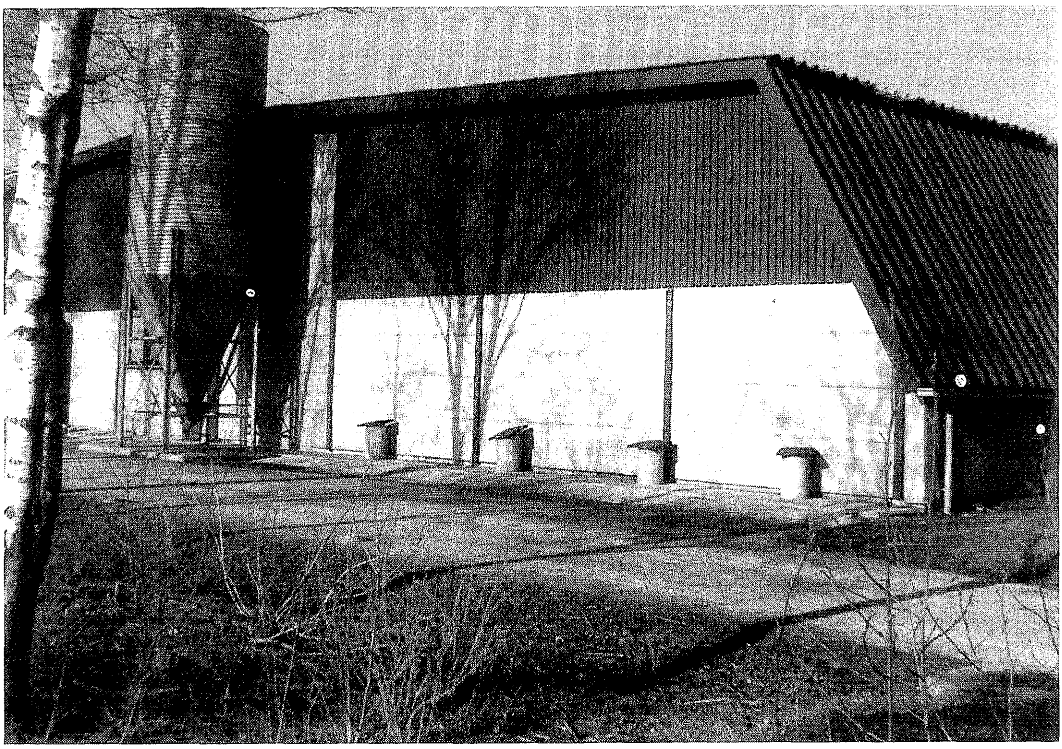

Dairy unit.

Organic dairy farming, present situation and questions for research

P.J.M. Snijders (PU-Lelystad) and
T. Baars (Louis Bolk Institute LB/-Driebergen)

Abstract

Organic farms do not use fertilizers and chemicals, they limit concentrate use and try to contribute to nature and landscape conservation and animal welfare. Because of the negative side effects of intensive dairy farming, interest for organic dairy farming is growing. About 10,000 ha is now used for organic farming, half of it for milk and beef production. Feed supply and quality, animal nutrition and profitability are the major concerns. Now the government is stimulating research on organic farming. Research concentrates on monitoring organic dairy farms, the use of forage legumes, manure application and system optimization.

1. Introduction

Dutch farming systems have become very intensive, owing in particular to market opportunities and land shortage. The growing concern about soil, water and air pollution, product quality, nature and landscape degradation and animal welfare has increased interest in more sustainable farming systems. At the same time stocking rates and milk quotas are decreasing.

Organic farming does not use synthetic fertilizers and chemicals, emphasizes a preventive approach to weed and pest control and animal health, and tries to contribute to nature and landscape conservation as well as biodiversity. Therefore its "pioneering" activities have met with growing interest and form a challenge to conventional agriculture. Whereas the concept of integrated agriculture, depending on its definition, also aims to integrate agriculture with other objectives such as a healthy environment, organic farming goes a step fut-ther.

His tory

Initially, organic farming was mainly a private initiative. Now the national and provincial governments are stimulating organic farming a.o. in regions with restrictions on land use. Recently additional funds have been allocated for research on organic farming. During the last decade specialized extension officers have been appointed to organic farming. In the seventies, the Agricultural University in Wageningen started research on biological pest control and now has a chair for ecological farming. The Louis Bolk Institute is a private research institution specializing in problems of organic farms.

There are two approaches towards organic farming: Biodynamic Farming (BD) and Ecological Farming (EKO). BD started early this century. EKO Farming started after the Second World Wat-, mainly because of concern about intensification. BD and EKO follow the standards for organic farming as indicated below, but BD has additional requirements.

Present situa tion and perspectives

At present there are about 500 organic farms in the Netherlands, using about 10,000 ha of land, which is about 0,5 % of the total used for agricultural purposes. The number of organic farms is increasing by more than 10 % per year, but they are dispersed over the country. Recently a successful cluster of organic farms was formed in Lelystad on clay soil, specializing in the production and marketing of vegetables.

There are about 150 organic dairy farms using about 5000 ha of land. The milk is mainly delivered to a few specialized dairy plants, paying about 15 % more than "conventional" dairies. In addition direct sale to consumers is of importance. Marketing of organic products is still a constraint. Production and transport costs are relatively high, but in particular the high retailing costs are an important reason for the high consumer prices of organic products. The group of consumers willing to pay substantially more for organic than for conventional products is limited. Improved marketing in particular, but also innovations and inventive management, cooperation with neighbouring (arable) farms and income generation from other activities may contribute to the perspectives of organic farming. Nature and landscape conservation, recreative and educational functions and for example employment of less able persons (as practiced by some BD farms), may combine better with organic than with conventional farming. There is an ongoing debate as to what extent (subsidized) nature and landscape conservation can integrate with agriculture: is complementary use possible, e.g. clusters of organic farms near larger zones for nature reservation or use of less fertile, drier or wetter sites within a farm for nature conservation?

2. **Rules for organic dairy farming**

The most important rules for organic dait-y farming are:

- No use of synthetic fettilizers and chemicals for weed and pest control and manufacturing of concentrates. Use of natural phosphates and potassium and for example toasted soybeans is allowed.
- Maximum of 20 % of feed energy as concentrates. For BD farms there is the additional requirement of limiting the total feed purchases (including silage) to 20 % of total feed use.
- Emphasis on preventive measures for animal and crop health and weed control. Curative medication of sick animals only as a last resot-t. Preference for non-allopathie means.
- Minimum of 120 days grazing per year on behalf of animal welfare.

Furthermore organic farms also aim to minimize loss of minerals, e.g. by integration of livestock and crops, to maintain or improve soil fertility and to keep close contacts with consumers. Organic products are sold under a special EKO trade mark. The quality is controlled by the Foundation for Quality Control of Alternative Agriculture (WAL).

3. **Characteristics and problems of organic dairy farms**

Characteristics of organic dairy farms

It is still difficult to characterize organic farms because of limited information and large variation between farms. Soil quality as characterized by moisture supply and fertility is very important, because opportunities to correct deficiencies causing poor growth are less than for conventional farming. Table 1 compares some results from specialized BD and EKO dairy farms to data from specialized conventional dairy farms. In 1989 average stocking rate was 1.2, 1.6 and 1.8 cows per ha grass and fodder crops respectively, EKO farms being relatively intensive. Feed costs were much lower on organic farms (despite higher costs for organic concentrates), while labour costs were higher. Milk production per cow and economic results were better for conventional farms. Farm size, milk production per cow, fixed costs and other characteristics vary tremendously and have a large effect on profitability. Some organic farms now have milk productions of about 8000 kg per cow. Recently, farm size has grown, in particular of some new EKO farms. The average size of 12 organic dairy farms on sandy soil visited in a recent diagnostic survey, was 35 ha (of which 8 ha for nature consewation), with 43 milk cows and a milk quota of 260 t (150-500 t). Most farms tended to specialize in milk production, for reasons of simplicity, limited farm size, and as yet limited opportunities for cooperation with arable farms owing to distance. A few sold cheese or kept some beef cattle as well. Grass/clover based

Table 1 Some indicative characteristics of specialized organic and conventional dairy farms in 1989 and 1992/1993 (the comparison has some limitations, e.g. a small number of organic farms!). Source: Agriculture and Economics Institute LEI-DLO.

	BD	EKO	BD+EKO	Conventional	
Year	1989	1989	1993	1989	1993
Number of farms	25	18	12	381	399
Area grass and fodder	28	25	45	27	29
Cow number	36	39	53	50	51
Cows per ha	1.2	1.6	1,18	1,8	1,75
Fodder area in grass %	77	81	85-90	90	88
Milk per cow	5380	5340	6280	6350	6780
Milk per ha	6600	8700	7400	11200	11850
Concentrates (kg/cow)			1100		2190
Feed costs (NLG per cow)	630	905		1207	

Landscape with botanically divers grassland

grazing and silage formed the main forage supply. In addition maize silage, and to a lesser extent fodderbeet and small grains, contributed. The BD farms visited, tended to have more land (mainly pasture) with restrictions for nature conservation, while EKO farms tended to import more minerals with manure.

Conversion to organic farming

Conversion to organic farming is more difficult for intensive farms, in pat-ticular on drought susceptible sandy soils. A transitional phase of 2 years is required before products can be qualified as organic. Farmers can get a limited subsidy during this period. The information/-advisoty service recommends conventional daity farmers to reduce the N application on grassland to 200-250 kg N per ha initially, in order to experience and facilitate the transition to organic farming. To ensure a sufficient forage supply, young stock numbers and milk quota are sometimes reduced, while extra land may be rented (e.g. land for nature conservation) or bought. After transition, perennial ryegrass/white clover and older botanically more diverse pastures form the basis for the forage supply. In pat-ticular farms with a high milk yield per cow experience a decrease after transition, also owing to lower concentrate supplementation, but they show some recovery thereafter.

Problems

The most important problems experienced by farmers, the information/advisory service and research are probably:

- Difficulties in maintaining soil fertility and lack of persistency of white clover, in particular on pastures on drought sensitive sandy or wet soils.
- Weed control in fodder crops in particular, but also in permanent pastures. Weed stress in fodder crops increases from small grains to maize to fodderbeet, particularly fat hen (Chenopodium album) being a problem in wet years. In pastures especially dock (Rumex obtusifolius), but also couch grass (Elytrigia répens) and thistles (Cirsium atvense) give problems.
- Production and quality of home grown fodder, in particular protein supply in winter, also owing to limitations on concentrate use. Insufficient information on intake, utilization and supplementation of grass/legume mixtures and mature forages from land with deviating botanica1 composition, in particular at low clover content (e.g. protein degradability).
- Animal health. Mastitis, in particular Staphylococcus aureus, is sometimes a problem. Hoof and fertility related diseases are sometimes found to occur less frequently on organic farms. Results are inconclusive however, be-

cause of limited information and possible interactions with for example level of milk production and type of housing. Use of antibiotics is lower on organic farms.
- Profitability and risk.

4. **Research priorities**

Research abroad and in the Netherlands has concentrated on the potential of grass/clover mixtures, with emphasis on management aspects, nutrition and variety testing. However other aspects like animal health and economics have also been studied. Research has not always been specifically targeted towards organic farms. Results indicate that yield and often clover content tend to be higher on good clay soils compared to more drought susceptible sandy soils. Red clover may improve the yield in young pastures, in particular under cutting. Intake of grass/clover mixtures tends to be higher than of pure grass, but results at farm level are less clear. Nutrient balances on organic farms show (much) lower surpluses and lower N losses than conventional farms. Very high clover contents may however still cause excessive leaching of N. For some years the potential of lucerne on sandy soils has been investigated. In a cooperative effot-t of research and the information/advisory service a number of organic farms are being monitored.
Based on the problems experienced and discussions amongst others in a PWLBI working group, the following research priorities can be identified:

Farming systems
Optimization of organic dairy farming systems. Integration of livestock with arable crops as well as nature and landscape conservation at farm and regional level, taking land suitability into account. To what extent can organic and integrated approaches support each other? Economic and environmental evaluation and risk analysis.

Management
Intensification of monitoring of organic farms (e.g. including feed quality, clover persistency on different soil types, changes in soil N and P status, animal health).

Productivity and persistency of grass/clover mixtures
Persistency of clover, in particular under sub-optimal conditions, e.g. drought sensitive sandy and wet soils. Effects of varieties and irrigation on clover, and possibilities of alternative species and crops. Better methods and criteria for renovation of grass/clover pastures. Recently, research has started on sod seeding and renovation in combination with shallow slurry injection.

Soil fertility and manure utilization
Effects of slurt-y and solid manure on grass/clover performance on sandy soils are being investigated by the Centre for Agrobiological and Soil Research and LBI respectively. PR is investigating effects of N and P fertilization on grass/clover and perennial ryegrass on clay soil. Optimal crop rotations to maintain soil fet-tility and to control weeds.

Weed con trol
Improved weed control in fodder crops and permanent pastures. The Research Station for Arable Farming is investigating weed control in maize.

In take, u tiliza tion and supplemen ta tion of grass/-clover mixtures and lucerne
Feed intake, protein utilization and supplementation are insufficiently known for grass/-legume mixtures as well as for botanically deviating and mature forages under the conditions and price relations of organic farms. PR and the Institute for Animal Nutrition and Health are investigating feed intake and feed value of grass/clover and lucerne and of supplementation with concentrates and maize silage.

Health management, milk production and quality
Monitoring of disease incidence and management to prevent diseases. Importance of milk yield per cow and breed. LBI is investigating several aspects of animal health, in particular mastitis.

In preparation is:
- Monitoring of organic dairy farms.
- System optimization and comparative experiments on station, in particular on sandy soils.

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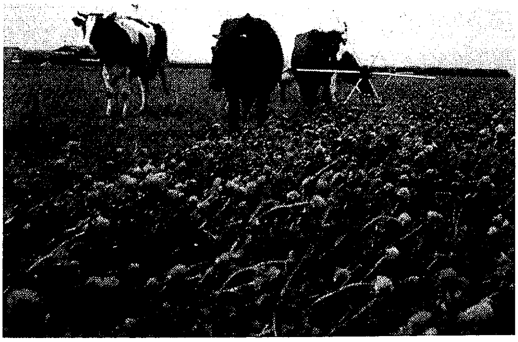

Colors in pastures through mixtures with red clover

Management of natura1 grassland with beef cattle

Mrs. H.G. Kuit and mrs. J.J. Heeres-van der Tol (PR-Lelystad)

Abstract

The decline in the diversity of the natural environment in The Netherlands has resulted in the development of a Nature Policy Plan. Its main objectives being a sustainable conservation, rehabilitation and development of landscape and nature. This objective will be partly realized by earmarking 250,000 ha as ecologically sensitive areas, consisting predominately of grassland. These natural grasslands are considered suitable for feeding suckling cows. This then offers perspectives for stocking large areas of nature reserves with beef cattle. The management systems could range from natural, very extensive grazing systems to semi-intensive farming systems. Also grazing in combination with arable land use could provide an attractive alternative integrated production system. Important aspects are co-operation with local farmers and economics. As the area of natural grassland will increases, the necessity to develop low-tost farming systems will gradually become more evident.

1 Introduction

1.1 Nature Policy Plan

The Dutch Nature Policy Plan aims at a sustainable conservation, restoration and development of nature (flora and fauna) and landscape values. One of the instruments to safeguard and extend these values is the allocation of 250,000 ha as ecologically sensitive areas, which are mainly under agricultural use nowadays. Approximately 200,000 ha of this area consists of grassland, representing about 20% of the agricultural grassland in the Netherlands. The remaining 50,000 ha is reserved for nature development (particularly wet areas).

1.2 *Nature management*

Actual grazing management of nature reserves is mainly executed by nature conservation organizations (NCO). Besides the management with proper livestock, the NCO's sell grass (hay) or lease pasture -under certain restrictions- to farmers for grazing dairy young stock and suckling cows. This method of nature management is very attractive due to the relatively low costs.

Lately, the interest of dairy farmers in leasing natural grassland has decreased, especially the less accessible grasslands. Since the introduction of the milk quotum system in 1984, the Dutch dairy herd has decreased by about 25%. A fut-ther decline is expected. Especially in extensive farming areas this has resulted in an on farm roughage surplus. In addition, restrictions on the mineral application (N,P) per ha has added to the decline in the number of cattle per hectare.

At this moment intensive discussion is taking place concerning the financial and technical management of the designated 200,000 ha of land: the cattle population is in decline and the area of nature grassland increases.

Approximately 100,000 ha will be managed by the individual farmer under cet-tain management agreements, the so called 'management agreement areas'. Depending on the type of agreement each farmer will receive financial compensation. Farmers will fit this grassland mainly in their dairy farm. The remaining 100,000 ha, the nature reserves, will be bought by the Dutch government and managed by NCO's. These organizations are investigating effective and eff icient ways of nature reserve management. Their preference is to manage these nature grasslands with grazing cattle in co-operation with local farmers.

2 **Beef cattle systems in nature reserves**

Important management tools in the presewation, conservation and development of natural grassland are grazing, manuring and stocking of cattle, resulting in a diverse landscape and environment. Depending on the characteristics and objectives of different areas, appropriate farming systems will be chosen. For instance, cattle are suitable for grazing (tall) grass, whereas horses and sheep also eat short grass and twigs. Consideration has also to be given to the farming system costs.

Mainly beef cattle breeds (suckling cows) are used for the management of nature reserves because they are labour extensive and can thrive on relative low quality fodders. The choice of a

breed depends on the type of nature reserve, possibilities for seasonal or year-round grazing, calving difficulties, tameness, colour and historica1 value. Besides French beef breeds also early maturing breeds like Scottish Highlander, Heck-cattle and Galloway are in use.
The management systems differ from natural with dynamic ecosystems with a minimum of human intetference, to more cultural (extensive) agricultural management.
In this range different beef production systems can be distinguished:

2.1 *Very extensive, year-round grazing system.*
This system is recognized as a very low-input system with low stocking rates: about 10-30 ha per livestock unit (L.U.), in which the cattle is part of the natural ecosystem. This grazing system is suitable for large areas consisting of forests, shrublands, grasslands, heathlands, etc. in a "landscape mosaic", managed by NCO's. Rustic breeds like the Scottish Highlander, Galloway and Heck-cattle are assumed to survive well under the more harsh conditions outdoors and without supplementary feeding.
The advantages of this system are the low costs (no housing, minimal fences, low stocking rate, minimum labour) and the possibility to manage large areas. There is no animal production goal.

2.2 *Cultiva ted extensive grazing system.*
This farming system is focussed on permanent grassland realized by mainly seasonal grazing. Characteristics are: smaller areas, the use of 'cultivated' breeds like Limousin, Charolais, Blonde d'Aquitaine and a higher stocking rate (-1 L.U./ha), compared to system 1. The suckling cows and offspring are housed in winter and fed silage and some concentrates. These farming systems are suitable for management in co-operation with farmers (see .3 Co-operation with farmers).

2.3 *Semi-intensive production system.*
This system can be characterized by a combination of grazing and mowing (for winter feed) of higher productive natural pastures frequented by meadow birds and transition areas (grassland managed without fertilizers and chemicals, which forms a buffer for clean water filtration into the core areas). This system is mainly managed by farmers and provides possibilities for beef production and to some extent for rearing dairy young stock. It is also attractive for ecological beef and/or dairy farming systems.

2.4 *Integrated farming system with arable land.*
Grazing in combination with crops as sugar beet, grain, peas etc. on the same farm makes it possible to integrate suckler and beef fattening husbandry. In practice, most cattle are sold at weaning and fattened intensively on other farms. It can be profitable to finish the bulls after two grazing seasons on a diet using crops and/or concentrates from on farm arable land or biological (nature oriented) farming. Meat from nature reserves has a potential added value, since the conditions and methods of production correspond with the consumers growing consciousness of the environment, nature, 'clean' meat and animal welfare.
This management is executed by some NCO's by themselves. It can be described as 'nature-farming', in which the nature values is the main objective.
The grazing areas in nature reserves are generally not highly productive and of moderate to low quality.
The fodder quality of natural grasslands with high botanica1 value is generally below that of rye-grass pastures (below 6,2 MJ net energy/kg dm) and therefore insuitable for intensive milk production. Research into ecological dairy farming concluded that the standard grazing system for intensive milk production is incompatible with the development of botanica1 values in grassland. Natural grassland with a net energy between 5,7 and 6,2 MJ is suitable for beef production (low productive rye-grass pastures, oat-grass meadows, marsh-marigold haylands and the crested dog's-tail grasslands); below this quality, the grass can only be used as litter.
However, stocking rates and seasonal fluctuations in fodder quality influence animal production. Therefore it is important whether the landscape has to be kept open and flat (grazing and mowing uniformly) or not. If differentiation of the vegetation is allowed -for example in integral grazing management of large nature units with low stocking rates- individual animal production will be enhanced, because the animals can then select their diet.

3 Co-operation with farmers

Farming systems mentioned previously are suitable for management in co-operation with farmers. Another possibility is management of nature reserves by the NCO themselves. Espe-

cially nutrient-rich grasslands can be managed by farmers. Nature areas with severe management restrictions can be managed by the NCO. There are several advantages to nature management in co-operation with farmers.
First of all it provides an oppet-tunity for integration of agriculture and nature. Another advantage is that farmers have the farming know how and possess machinery and buildings, reducing the running costs. When farmers are employed by NCO's they earn a fixed salary (as civil servants) independent of the farm results. In this case less attention could be paid to labour efficiency and investment costs. Such farms are capital intensive. Generally, cattle farmers have more feeling for animal husbandty aspects but realize the necessity to work overtime.

In the case of nature management in co-operation with farmers, financial compensation and lease contracts are important. At this moment short term (one year) contracts are possible. The Agricultural Holding Act for Nature Purposes makes long-term leasing possible, giving the farmer more continuity and security for the development of a farming system. Financial compensation is realized by a reduction in rent. In these contracts agreements are made about the management, i.e. no use of fertilizers and chemicals and an appropriate mowing regime. An important condition is a good relationship between the NCO and the farmer. The latter has to understand the nature objectives and implement the management in a professional way.

An other possibility are the 'nature co-operatives', regional initiatives have been set up. This shows that farmers are becoming more concerned about nature and environmental issues and try to anticipate on governmental regulations in an organized way. There is an increase of 'nature-co-operatives', set up by farmers for co-operative management of nature and landscape in a cet-tain region. For example, in Waterland (North-Holland) such a co-operative developed grassland management in consideration of nesting birds, which has become a national success. The advantage of nature co-operatives for farmers is that in this way they can discuss directly with (local) government about the nature goals, management conditions and financial compensation. For the government this approach means a reduction in costs for the acquisition of land. Besides regional initiatives, beef cattle farmers have shown interest in nature management at national level. The Dutch Federation of Beef Cattle Herd-books recently announced that 288 farmers would be interested in grazing their herds in nature reserves, accounting for over 10,000 suckling cows. In fact, more than 50% of these farmers are also ready to move their farms to the border of these nature reserves.

Finally, it s important that the government together with the NCO's and cattle farmers implement the Nature Policy Plan. An important key-factor to its success is the inter-dependence of NCO's and cattle farmers. Beef cattle producers will benefit from the larger areas as well as from a positive 'natural' image. The NCO's benefit is the supply of the large amount of cattle needed for the grassland management.

4 Economical aspects

Generally, nature management is an expensive activity.
A theoretical study on farm economics of suckler husbandry based on only natural grassland with a high botanica1 value, showed nagative operating results (-850 to -1005 Gld/ha, depending on the type of grassland). This has been studied for farms of 300 ha with stocking rates between 0.4 and 1 .O L.U./ha, managed by two full time workers. Calves are sold after weaning and the cows are housed in winter. Studies on suckling husbandry on peat grassland (grassland with special function for meadow birds) also showed negative results; in the most favourable situation income covers the costs. Because of these negative results, beef cattle farming on natural pasture is seen mostly as a side-line business for farms with a shortage of fodder and a surplus of labour.
Important economical factors influencing the overall farm results are land-prices, interests, farm size, number of animals and farm buildings. Also price-sensitivity is an important aspect, as is the case for meat prices. Possibilities for minimizing costs have to be studied. To what extent is housing necessaty, what are the minimal housing requirements? Lowering the number of animals (lower stocking rates) can reduce the costs, but also lowers the income. From this point of view, extensive farming systems using Scottish Highlanders for example have to be compared with cultivated French beef

breeds. Running costs could be more or less the same. Other aspects like manure-storage and processing, litter requirements and labour also have to be considered.

Management-costs can fut-ther be reduced, using governmental subventions. These possibilities have not yet been fully employed.

5 Discussion

Nature management with beef cattle will become more important if the area of natural grassland is enhanced in accordance with the Nature Policy Plan.

In actual fact, much attention must be paid to organized nature management by farmers: monitoring and evaluation projects of agrarian nature management are petformed, and there are possibilities for financial support and legal adjustments to ensure nature values on farmers' land. In addition, land-structuring programmes should incorporate low-tost cattle farming systems. Possibilities for settlement and upgrading of extensive beef farms should be investigated.

The feasibility of various production systems has to be studied. Management alternatives such as year-round grazing on dry grassland and transhumance systems (in which the herd moves seasonally from one area to another), have to be considered. Monitoring of existing beef production systems in nature reserves and results obtained from model-studies, should throw more light on this subject.

Besides cost reduction, increase in income from nature management should also recieve attention. Although the marketing of beef from nature reserves under label has not yet been undettaken seriously. The Dutch Meat Board has indicated that this could lead to a niche-market. At present, there is an increasing demand for beef from local farms involved in nature management. Special quality meat from nature reserves is also offered in some restaurants. This may offer perspectives for beef cattle farmers to develop specific nature oriented production systems. A chain organization (or farm co-operative) could provide a profitable alternative for mutual exchange of needed inputs and efficient marketing. Continuity of supply and quality of the meat, as well as its marketing, is very important.

6 Conclusion

Nature management with beef cattle will become more important if the area of natural grassland is enhanced in accordance with the Nature Policy Plan. Extensive beef cattle production under set conditions for management of natural grassland is promising, especially when considering the added marketing value of the meat. Attention must be paid to organized nature managment by farmers.

Support from the Dutch Government and EU for farming in relation to nature is important for the diversity and quality in agricultural production and improvement of the environment (nature and landscape values).

More research has to be undertaken on technical, economical and social aspects. Organization of farmers, policy-making for settlement, adjustments of farm structures and marketing are all important issues towards the development of innovation in a sustainable land use.

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A methodical way to more sustainable cattle and sheep grazing systems

Mrs. C. Hermans (DLO Winand Staring Centre for Integrated Land, Soil and Water Research SC-DLO-Wageningen) and P. Vereijken DLO Research Institute for Agrobiology and Soil Fertility AB-DLO- Wageningen

Abstract

The Netherlands is a typical area of intensive animal husbandry far beyond the carrying capacity of a sustainable agro-ecosystem. Therefore, we designed Sustainable Nutrient Management as a farming method for rendering grazing animal husbandry soil-bound, again. At farm level Sustainable Nutrient Management has been elaborated into a quota system for stocking rate and milk production per hectare. This article deals with the question of how farms can change over to Sustainable Nutrient Management and adapt to Sustainable Stocking Rate and Sustainable Quota for Milk production throughout the Netherlands. Changing over to Sustainable Nutrient Management mostly implies extensification by reducing the stocking rate to Sustainable Stocking Rate and the milk quota to Sustainable Quota for Milk production. As a result, area of land should increase and/or premiums per hectare or per kg of produce should become available. This will ensure economic sustainability by achieving a Net Operating Result of at least O.- ECU. Therefore, we designed a methodical way for restructuring farms in four steps to achieve both Sustainable Nutrient Management and a Net Operating Result of at least O.- ECU. This methodical way is presented by restructuring an existing dairy farm in the east of the Netherlands as an initial test case. Before it can be used as routine throughout the Netherlands, it should be tested and improved according to four criteria which should be successively fulfilled: has the methodical way been elaborated sufficiently, is the methodical way manageable, is it acceptable and is it effective.

1 Introduction

In the Netherlands, the number of grazing animals are higher than can be fed by the area available for herbage production. Since the area available for arable crops is used to produce more profitable products for human consumption, large quantities of additional feed has to be imported. Because the nutrient inputs via this additional feed is almost twice as high as the nutrient outputs via milk and meat, large surpluses occur on the nutrient balance sheets of the average grazing husbandry farm. As a result, in large parts of the country soils are saturated with nutrients which are leaching to groundwater and sutface water exceeding national standards for water quality.

Recently, we proposed Sustainable Nutrient Management (SNM) as a technology for preventing or cleaning up nutrient surpluses and associated environmental pollution. It implies the tuning of inputs to outputs of nutrients to achieve and maintain optimum ranges of agronomically desirable and ecologically acceptable reserves of single nutrients in the soil. SNM should focus on P which may act as the ‘boss cow of the nutrient herd' and thus may allow to confine the management of the remaining nutrients as K and N. In the Netherlands, availability of P on grassland is expressed as the P-AL count. The agronomically desirable range on most of the soil types has been established as a P-AL count of 30-55. We assume this range is ecologically acceptable on most farms, unless the sorption capacity of the soil is limited owing to a high groundwater level or a low pH. P input in concentrates may equal P output in milk and meat as long as the level of available P-soil reserves is within this range. A P-AL count greater than 55 is agronomically unnecessary. Therefore, we propose no longer considering it ecologically acceptable. At a P-AL count of 55-100, surplus P-soil reserves should be gradually reduced, by no longer compensating P output via milk and meat with P input via concentrates. Therefore, concentrates are to be produced on-farm resulting in a net P output in milk and meat of 8-10 kg/ha yr. At a P-AL count greater than 100, surplus P-soil reserves need to be reduced as fast as possible because they will cause leaching on many soils. For the farm or field in question, this implies termination of animal husbandty and removal of all crop produce resulting in a net P output of 30-35 kg /ha/yr.

At farm level, we have elaborated SNM into a quota system for stocking rate and milk production. The Sustainable Stocking Rate (SSR) is defined as the number of livestock units (LU[1]) which can be fed by 1 ha of herbage crops and, provided that the P-AL count is less than 55, by an amount of purchased feed P equivalent to the output of milk and meat (in LU/ha). Rearing and fattening of redundant youngstock should be included in SSR to make it soil-bound, too. The Sustainable Quota for Milk production (SQM) is defined as the amount of milk (4 % fat) which can be produced at SSR (in kg/ha).

This article deals with the question of how, throughout the Netherlands, farms can change over to SNM and adapt to SSR and SQM. The answer is a methodical way for restructuring farms in four steps. We present this methodical way of four steps by restructuring an existing daity farm in the east of the Netherlands as an initial test case. The farm is representative of dairy farming in the Netherlands on sandy soils. Besides, it is adjacent to a nature reserve and negotiating changing over to SNM to protect the reserve against eutrophication. Termination of the farm is not considered.

[1] 1 livestock unit (LU) is equivalent to an annual net energy need (MJ) of a 600 kg cow producing 6,000 kg of milk 4% fat (standard cow).

2 Materials and methods

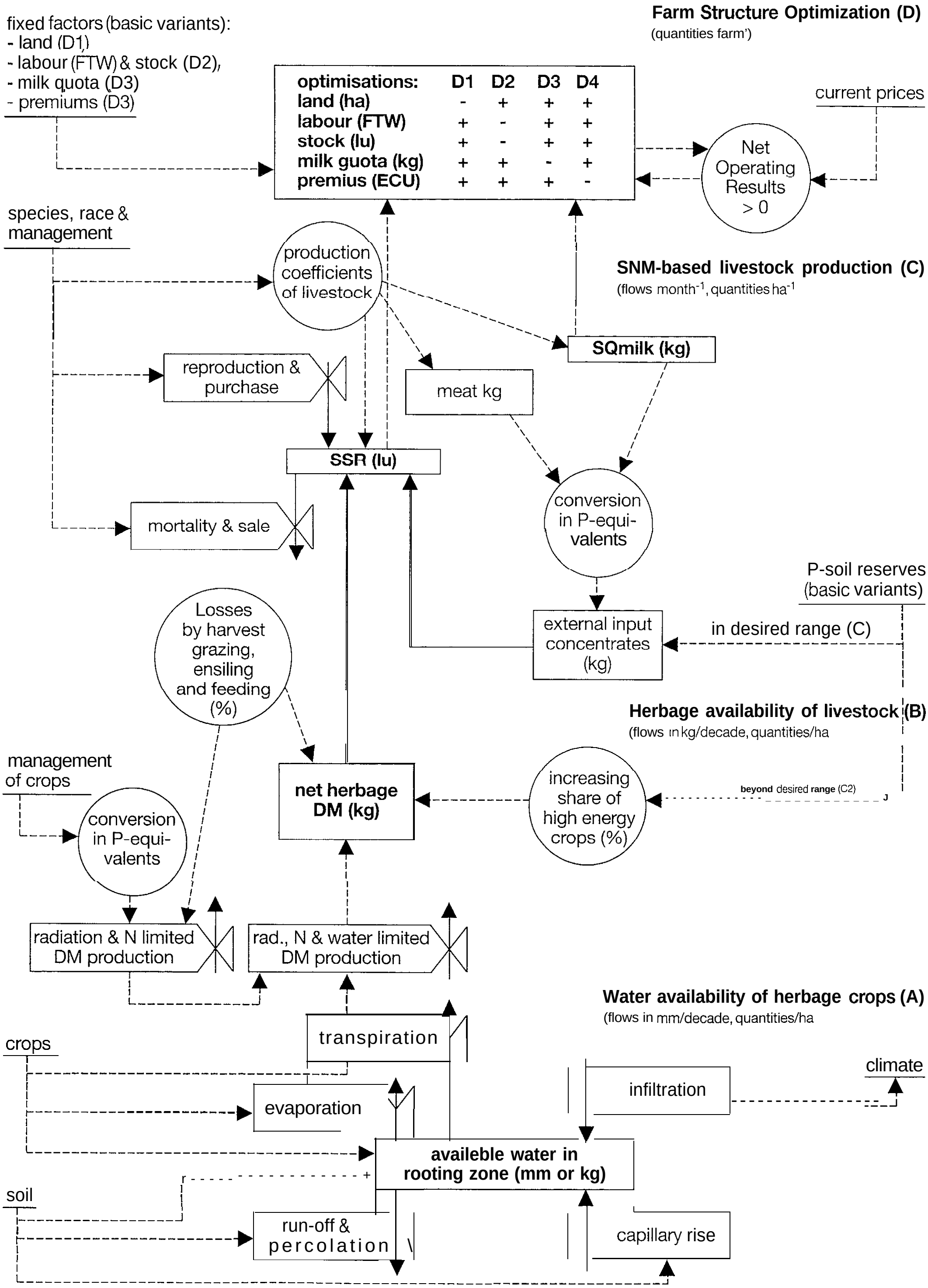
2.1 *General outline of the methodical way for SNM*

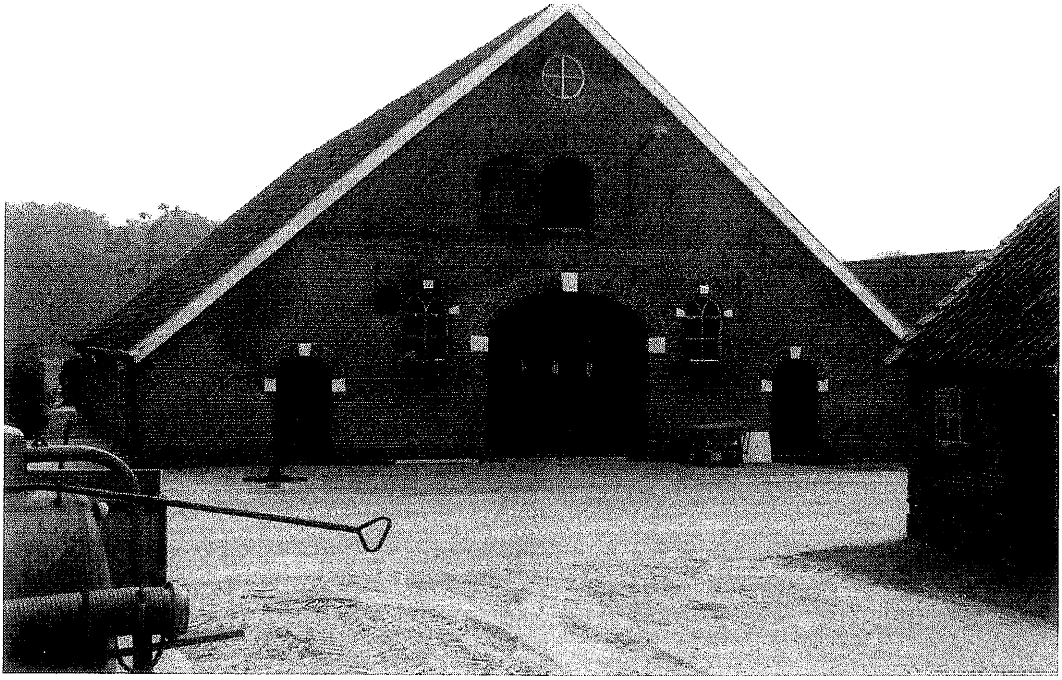
Figure 1 presents an outline of the methodical way in four steps for SNM ensuring a Net Operating Result (NOR) of at least O.- ECU. NOR is the difference between all returns and all costs, including own labour costs. The first three steps (A, B, C) deal with the problem of assessing SSR and SQM of farms in a sufficiently objective and accurate way, thus field by field. The fourth step (D) deals with the economic optimization of the farm structure. In step A, water availability of herbage crops is quantified based on local conditions of soil and climate. In step B, herbage availability of livestock is quantified based on available water in the rooting zone and management of crops. In step C, two variants are made with respect to P-soil reserves to show

The test farm is situated in de eastern, sandy region of the Netherlands near Enschede.

Figure 1 General outline of the methodical way in four steps for restructuring grazing animal husbandry farms changing over to Sustainable Nutrient Management.

Rectangles are quantities (state variables), valves are flows (rate vanables), circles are auxiliary vanables, underlined vanables are driving or external variables. full lines are flows of material, dashed lines are information flows.





their possible implications for the eventual farm structure. In variant Cl, all fields on the farm have P-soil reserves in the optimum range (P-AL count of 30-55), so external input of concentrates is allowed. In variant C2, all fields have P-soil reserves beyond the optimum range (P-AL count of 55-100), so concentrates have to be produced on-farm which has implications for the area of various herbage crops on the farm. For each variant SSR and SQM are calculated. In the last step D, farm structure is optimized based on current price levels. Required premiums per hectare or per kg milk are calculated to achieve a NOR of at least O.- ECU, if area of land (variant Dl), labour capacity and related number of stock (variant D2) or milk quota (variant D3) are limited. If premiums are not available, area of land is increased to achieve NOR of at least O.- ECU (variant D4).

2.2 *Description of the farm serving as an initial test case*

The test farm is situated in the eastern, sandy region of the Netherlands. It has a cultivated area of 21 hectares, covering 7 soil types. The dairy herd is comprised of 35 dairy cows (Holstein-Friesian and Friesian-Dutch) and an equal number of youngstock, 57 lu in total. Average milk production per cow per lactation is 6,970 kg (4.72% fat). The farm milk quota is 265,000 kg (4% fat). External input of concentrates per cow (including youngstock) is 2,155 kg/yr. P, K and N surpluses on the nutrient balance sheet are 38, 173 and 496 kg/ha/yr, respectively.

3 Results

The four steps of the methodical way (Fig 1) have been initially tested on the farm described. The results are presented in Table 1.

Water availability (step A) varies between soil types for the same crop, due to variation in maximal rooting zone of soil types and ground-water levels. Water availability also varies between crops on the same soil type, due to variation in length of growing season and maximum rooting depth of crops. So, water availability is the result of the interaction of soil and crop characteristics.

Based on available water in the rooting zone (step A), herbage Dry Matter (DM) (step B) is calculated and it varies between crops. Variation is due to different transpiration coefficients, harvestable fraction and N-recovery coefficients. The share of area of land per herbage crop is related to the P-AL count of the fields on the farm. At P-AL count 30-55 on all fields (variant Cl), input of concentrates is allowed so only grass and maize are produced. At P-AL count

Table 1 Restructuring grazing animal husbandty farms changing over to Sustainable Nutrient Management in four steps: farm existing dairy farm as an initial test case.

Step A and B (first part). Water availability and production of herbage crops.

Soil type	Grass[1]			Maize[1]			Fodder beet		
	Area (ha)	Available water (mm)	Herbage DM (t/ha)	Area (ha)	Available water (mm)	Herbage DM (t/ha)	Area (ha)	Available water (mm)	Herbage DM (t/ha)
Hn51	3.2	440	8.8				3.2	330	12.4
Hn 52	5.1	510	10.3	0.9	340	9.7	6.0	350	13.3
tzg53	1.1	530	10.6				1.1	350	13.3
Tzg55	1.1	590	II.7				1.1	360	13.6
czg55	3.1	640	12.9				3.1	360	13.6
zEZ53	1.8	500	10.0				1.8	400	15.0
dzEZ53				4.2	400	II.3	4.2	420	15.8
Weighed		530	10.6		390	11.0		370	13.5
			8.4[2]			9.9'			12.22

Step B (second part). Herbage availability of livestock

Basis variant P-AL count	CI 30-55			c2[3] 55-100			
	grass	maize	total	grass	maize	fodder beet	total
Share of area of land	0.86	0.14	1.0	0.73	0.12	0.15	1.0
Share of net herbage DM (t/ha)	7.2	1.4	8.6	6.1	1.2	1.8	9.1

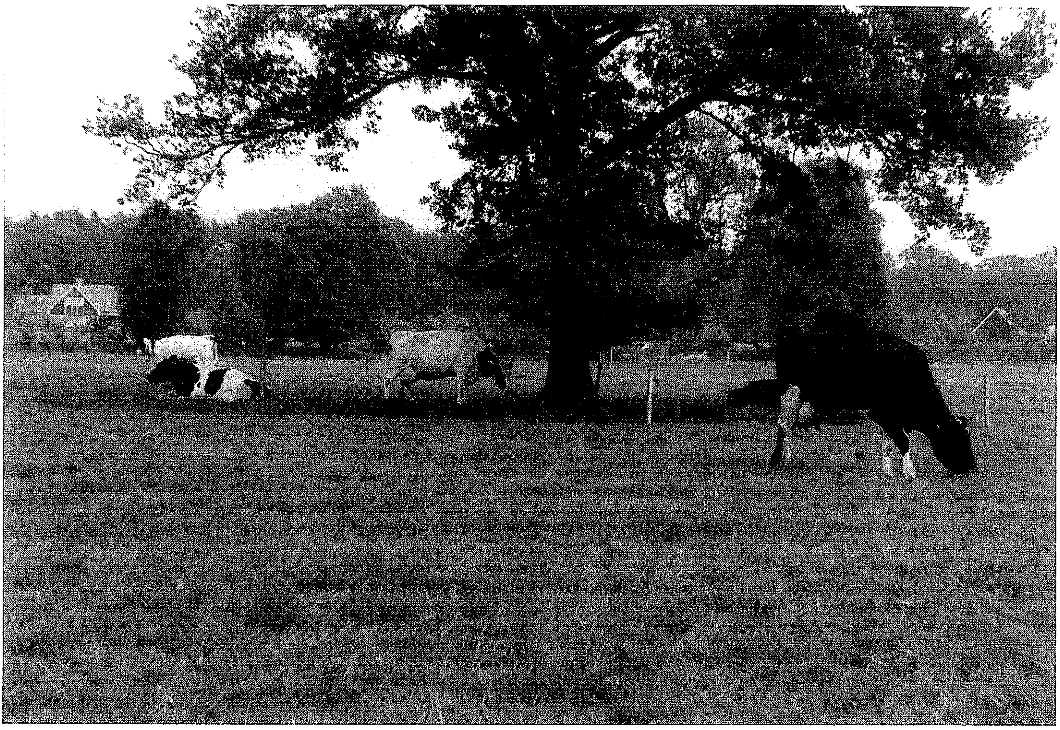
Step C. SNM-based livestock production

Basis variant P-AL count	CI 30-55	C2[3] 55-100
Net energy available (10^3 MJ/ha)	68	58
- herbage	53.0	58
- external conc.	14.3	
SSR (lu ha^{-1})	2.0	1.71
- dairy cows	1.41	1.23
- replacing youngstock	0.24	0.20
- fattening youngstock	0.35	0.29
SQM (kg ha^{-1})	8,750	7.650

Step D. Farm Structure Optimization[4] (fixed factors underlined).

Basis variant	DI		D2		D3		D4	
	CI	c2	CI	c2	CI	c2	CI	c2
Land (ha)	21	21	29	33	30	35	73	90
Labour (FTW[5])	0.93	0.69	1 10	1.10	1.14	1.12	2.06	2.13
Stock (lu)	41	35	57	57	61	60	147	154
Milk quota (t)	180	155	250	255	265	265	655	690
NOR (10^3 ECU[6])	-46	-44	-41	-42	-39	-40	1	0
Premiums[7]								
(ECU ha^{-1})	2,200	2,100	1,400	1,200	1,300	1,200		0 0
(ECU kg^{-1} milk)	0.26	0.28	0.16	0.16	0.15	0.15		0 0

Calculations only for soil types actually in use at the farm for grass or maize productron.
Net herbage DM (t/ha) = Radiation- and water limited DM (t/ha) - losses by harvest, grazing, ensiling and feeding.
External concentrates implying P input are replaced by a high energy crop such as fodder beet.
Results rounded off at 1-7 % accuracy.
1 FTW = 2,237 hours/year (natronal standard for grazing animal husbandry farms.
1 ECU = ƒ/ 2.12.
Premiums required to archieve a net Operating result (NOR) of O.- ECU.



Compared to the present stocking rate and milk quota at the test farm, a considerable extensification is required to ensure Sus tainable Nu trien t Management.

55-100 on all fields (variant C2), input of concentrates is no longer allowed, so it has to be produced on-farm. We have chosen for fodder beet as a concentrate. So, besides grass and maize, fodder beet is grown. The share of maize in both variants is related to the number of dairy cows all fed 3 kg DM maize silage daily.

Based on net DM available from herbage (step B) being 8.6 t/ha in variant Cl and 9.1 t/ha in variant C2, and possibly external concentrates, SSR and SQM are calculated as 2.0 lu/ha and 8,750 kg/ha in variant Cl and 1.71lu/ha and 7,650 kg/ha in variant C2 (step C). Comparing SSR and SQM of Cl and C2 to the present stocking rate at the test farm of 2.5 lu/ha and milk quota of 13,000 kg/ha (4 % fat), a considerable extensification is required in both variants of P-soil reserves.

After extensification of both variants of P-soil reserves (step C), economic optimization of the farm structure is needed to assure a NOR of at least O.- ECU (step D). In variants D3, for instance, the farmer would consider the present milk quota of 265 ton as fixed. Now, he should increase his area of land of 21 ha by 9 (D3C1) or 14 (D3C2) ha in order to change over to SNM. He should increase present stock of 57 lu by only 4 (D3C1) or 3 (D3C2) lu, since present milk production per cow is fairly close to SNM-based milk production. Because none of the D3 variants can achieve a NOR of O.- ECU, premiums per hectare should be 1,300 (D3C1) or 1,200 (D3C2) ECU. Alternatively, a premium of 0.15 ECU per kg of milk is required in both variants. The same reasoning holds for the other variants.

4 Conclusion and recommendations

This at-ticle presents an initial design for SNM as a farming method for rendering grazing animal husbandry soil-bound, again. Moreover, it presents an initial test on a representative commercial farm. The results on the test farm show that changing over to SNM implies extensification by reducing the present stocking rate of 2.5 LU by 0.5 (variant Cl) to 0.8 (variant C2) LU to SSR and the present milk quota of 13.000 kg ha-1 by 4.250 (variant Cl) to 5.350 (variant C2) kg ha-1 to SQM. As a result, area of land should increase and/or premiums per hectare or per kg of produce should become available to ensure the economic sustainability (a basic income in conformity with national payment standards for land labour) by achieving a NOR of at least 0.- ECU.

Taking into account the large surpluses on the balance of the 'national grazing animal husbandry farm' of about 80 million kg P, combined with the large area, about 80 %, with a P-AL count in or beyond the agronomically desirable range, it is obvious that if applied throughout the Netherlands, SNM will extensify grazing animal husbandry. It has been calculated that is would result into a reduction in stocking rate of about 40 % and a reduction in milk production of almost 35 % compared to 1991.

Before the methodical way can be used as routine throughout the Netherlands, it should be tested and improved according to four criteria which should be successively fulfilled:

- has the methodical way been elaborated suff iciently?
- is the methodical way manageable?
- is the methodical way acceptable?
- is the methodical way effective?

According to these four criteria, it should be explored stepwise where and how the methodical way should be improved in order to be used as routine on a large scale.

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Integrated animal and veterinary sciënce for sustainable dairy farming

A.J. van der Zijpp (DLO-Institute for Animal Science and Health ID-DLO-Lelystad)

Sustainable daity production

Sustainability has become a multi-functional term. The sustainability of a system has been defined as renewable resource use, technical feasibility, economic viability and social acceptability. Interpretation of the term sustainability is related to questions about space allocation, timescale, environment, ecology, economy and social and cultural values. Sustainability regards control of development, alternative production systems and diversity of goals. Each era has defined its specific models. We are now approaching the sustainable era: optimization of complex biological production systems with socio-economics. Optimization here means the combination of renewable resources, technical expertise, economic viability and social acceptability. This trend may lead to diversification in production systems: satisfying consumers of dairy products and securing rural development. This is a great challenge for research on dairy production. Many facets of the production process have to be studied and combined to design a feasible system. Moreover, these farming systems have to function regionally. Finally they have to affect the production chain in order to satisfy consumers of dairy products, landscape (tourism) and inhabitants (neighbours) as well and secure income for the dairy farmers.

Mission of the DLO-Institute for Animal Science and Health

In december 1993 the Minister of Agriculture, Nature Management and Fisheries created a new institute: ID-DLO. ID-DL0 combines animal and veterinary sciences and therefore has unique oppottunities for supporting research on sustainable animal production systems.

Our mission is to generate, utilize and transfer scientific knowledge and expertise to develop sustainable animal production systems. Our research is oriented towards the functioning of the whole animal. Major goals are improvement of welfare and health, quality and safety of food and products, as well as the environment. This is integrated with efficiency of production and a high, added value in the production chains for meat, milk and eggs.

Our contribution to sustainable dairy production systems is linked mainly to use of natural resources and technical solutions. By co-operation between the Dutch and international animal production research network as well as veterinary science networks, we hope to contribute developing the socio-economie components.

Research and services

The research programme of ID-DL0 is problem based. The level of research: basic, strategic and applied is appropriate for the problem that needs to be solved. Therefore some programmes have a scope of at least 10 years, whereas others should have an impact on dairy farming in the short term.

The research programme is divided into five areas:

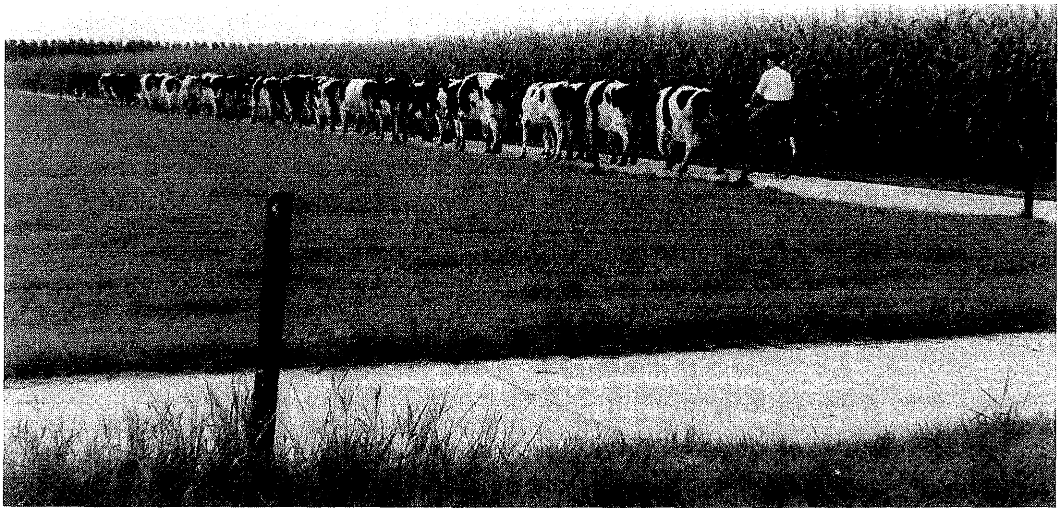
- genetics, breeding and reproduction
- housing and management
- nutrition, including quality of grass and silage
- animal health, including the development of vaccines and diagnostic techniques into products
- quality and safety of animal products

We operate approximately 20 research programmes, each of 4 years in duration. Each year some of these programmes are renewed. The expertise for these research programmes is developed in fout-teen departments for research and production of animal medicines and diagnostic products. The demand for research topics dictates the types of disciplines and the number and size of disciplines. In financial terms half of our research is supported by the Ministry of Agriculture, Nature Management and Fisheries and half of our research is contracted by industry, national and international.

Major emphasis in future will be on research integrating pathogens, animals and their environment. Basic specialist, monodisciplinaty support is needed to investigate this trianglar relationship. Examples are research at the molecular and DNA level, both for pathogens and the whole animal. The triangle is also the basis for the study of interactions at farm and population level. Results of our experimental research, sometimes of a very complex nature, involving pathogen(animals and environmental factors have to be transferred to field experiments. Here, the research stations and the regional animal health services support the testing of new systems, management and products in more complex conditions. At the same time acceptability of these new technologies for the users is identified and possibly also their economic advantages. Illustrations of research projects on genetics and health, reproduction and health and nutrition, health and stress and management of daity cattle will be presented.

Conclusion

Sustainability is a multifaceted concept. ID-DL0 is a multidisciplinaty institute combining animal science and veterinary science. The challenge for the future, in the long term, lies in analysing the correct problems and finding acceptable technologies to solve them.



Environmental pressures on dairy farming in the UK

C. Thomas and J.A. Bax (SAC, Ayr - Scotland)

Introduction

During the last 10 years there has been a fundamental shift in government thinking towards agriculture, with a move from production orientated policies to a position which now takes more regard of the environmental consequences of the industry. Increased awareness of pollution, loss of habitat, inappropriate financial support mechanisms and over production within the EC has changed the politica1 balance. Increasingly, government policy is moving towards a 'greening' of agriculture and the promotion of sustainable farming systems. This is being implemented via a range of measures, both fiscal and legislative, assisted by the continuing high level of agricultural support that is central to the Common Agricultural Policy. Currently, in the UK, the dominant influence on dairying is from legislative measures put in place to reduce the environmental impact from silage effluents, animal wastes and nutrient inputs. This is most notably enforced via the UK legislation 'Control of Pollution Act' and the imminent creation of Nitrate Vulnerable Zones as a consequence of the EU Nitrate Directive (91/676). However, the range of environmental measures now in place in the UK to improve biodiversity within farming systems has not yet altered dairying activities to any significant degree. A concomitant shift in research priorities has also occurred during this period with an increased emphasis on developing techniques for biologically and financially sustainable dairying systems and for reducing the pollution potential of dairying.

The future direction of the UK dairy industry is unclear due to the uncertain future of milk quotas under the CAP and the renegotiation of GATT combined with the recent deregulation of the milk processing industty. The most probable result is a reduction in milk price. As a consequence there is likely to be an acceleration of the current trend towards developing either lower input/moderate yield dairy systems or higher input/higher yield systems. The development of sustainabie systems will be driven more by the economics of market forces than by government intetvention.

Current position in the UK

Environmental measures fall into two broad categories. The first includes the legislation relating to farming activities and the pollution that can result, whilst the second includes a range of measures to encourage reductions in the intensity of farming and to enhance the environment and its biodiversity. The second categoty tends to be targeted at the less intensively farmed areas of the UK, covering aspects such as habitat creation and increased public access to the countryside. As a consequence they have had a limited impact on dairy farming. For example environmentally sensitive areas (ESA's) have been established throughout the UK to encourage farmers to help safeguard areas of the countryside where the landscape, wildlife or historic interest is of national impottance. Currently 22 areas in England have been designated as ESA's covering approximately 10% of all agricultural land. There are a further 10 ESA's in Scotland covering 1,439,000 ha. However, few dairy farms are located in these areas. Participation by a farmer in the scheme is voluntary and in general if a dairy farm enters the scheme the only requirement is to observe the standard code of good agricultural practice intended to prevent environmental pollution which applies to all UK farmers.

By contrast the legislation relating to pollution arising from agricultural activity is having a direct impact upon dairy farmers. In Scotland the Control of Pollution Act 1974, supplemented by the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) (Scotland) Regulations 1991 provide the statutory framework within which all dairy farmers must now operate. The measures are aimed primarily at preventing pollution of water courses or ground water. Arising from the legislation there is a code of good practice for the Prevention of Environmental Pollution from

Agricultural Activity (PEPFAA) which should be followed by all dairy farmers.

The main provisions to affect dairying under the PEPFAA code are:

- Maximum application rate of 50 m^3 in any one application of slurry, manure or dirty water. Injected slurry rate should not exceed 100 m^3/ha.
- Repeat applications should not be made for at least 3 weeks.
- There is no limit to the total amount that can be applied in a year, provided that no direct pollution to water supplies or water courses occurs.
- There are no restrictions on period of application.
- Six months storage capacity for slurries is required, unless under a formally agreed Waste Management Plan drawn up with the local water authority, it can be shown that a lesser capacity will not result in a greater risk of pollution.

In practice it means that slurry storage capacity on the majority of dairy farms in the UK, is considerably less than 6 months. However, if a pollution incident does occur the maximum penalties following conviction are a prison sentence not exceeding 3 months and/or a fine not exceeding £20,000. In practice, the fines are normally considerably less. A policy of education rather than punishment is persued by the authorities as demonstrated by the limited number of prosecutions initiated (Table 1). Similarly in 1993, whilst only 15 prosecutions were commenced, a fut-ther 129 warnings were issued which had the desired effect of producing improvements at farms where structures were not up to standard.

After a pollution incident the Waste Management Plan will be reviewed by the authorities and it may be decided that the storage and disposal system would require upgrading. As grant aid towards investment in pollution control is no longer available it is an added incentive for preventing any pollution incidents. Currently there are no stocking rate restrictions and no limits on atmospheric discharges of pollutants such as ammonia.

Table 1 Prosecutions resulting from farm waste pollution incidents (Scotland 1994)

Number of prosecutions	Type of incident
3	silage effluent
6	cattle slurry
1	farmyard manure effluent
1	pig slurry

There is however the future prospect of restrictions on inorganic and organic nitrogen use in the proposed Nitrate Vulnerable Zones. The legislation is still in the consultative stage, but it is likely to affect an area of approximately 600,000 ha in the UK. The number of dairy farms located within the proposed zones is not known yet. The two main proposed management restriction are that:

- Inorganic N should not be applied between 1 September and 1 Februaty and the amount should match the requirements of the crop.
- Applications of total organic N from both grazing cattle and the application of stored manures should not exceed 210 kg total N/ha/year initially, reducing to 170 kg N.

The restrictions on total organic nitrogen applications will require significant changes in management for any dairy farms that fall within the proposed Nitrate Vulnerable Zones. If the regulations are applied on an animal basis the initial maximum limit of 210 kg N/ha equates to a stocking rate of 2.2 livestock units/ha on an all grassland dairy farm. To meet the eventual limit of 170 kg N/ha will require a further reduction in stocking rate to 1.7 livestock units/ha (P Johnson pers comm). To put this into context, existing efficiently managed all grassland extensive dairy systems can be stocked at 2.0 livestock/ha (Bax and Thomas 1992). If the regulations are applied on the basis of a nitrogen balance there may be scope for reducing the impact of the legislation by manipulating nitrogen efficiency in the cow.

Research and development of sustainable dairy systems

Research priorities have changed to match the shift in government policy. The long term research input into understanding rumen N transactions is now supplemented by research into soil N processes, nutrient efficient forage production, and animal health and welfare to provide the framework for a holistic approach to financially and biologically sustainable dairy production systems for the future. A biologically sustainable dairy system is generally accepted

Table 2 The effect of the efficiency of use of amino acids on nitrogen efficiency

No cows	Milk yield	Concs (kg/l)	Knl	Milk N/Urine N N	Urine N (kg/h/annum
200	5000	0	0.600	0.64	104.0
150	6700	0.3	0.60	0.70	201.6
150	6700	0.3	0.65	0.77	183.4

as one that maximises the efficiency of use and recycling of nutrients whilst minimising both the loss and the import of nutrients. Developing such a system is not straight forward.

If urinary nitrogen is used as a base to describe nitrogen efficiency and losses in the dairy cow it is possible to predict the consequences of changes in its management (Dewhurst and Thomas 1992). If for example milk yield is raised by increasing concentrate inputs, the replacement of forage with concentrate would normally enable the stocking rate to be increased. Increasing concentrate inputs at the same efficiency of utilisation of amino acids for milk production (Knl) increases the milk N/urine N ratio due to the dilution of maintenance and potentially increased microbial efficiency. However, in the practica1 situation any alterations in efficiency would be overcome by changes in the stocking rate (Table 2). Even if Knl could be improved for example by genetics or by increasing the efficiency of amino acid utilisation the effect on urine N/ha would be marginal, with stocking rate still the dominant factor.

Legumes have considerable potential for sustainable dairy systems, due to their ability to fix atmospheric nitrogen and grass/white clover swards are a key component in current extensive dairy systems. However, when cows graze clover rich swards there can be a gross oversupply of dietary nitrogen in relation to fermentable metabolisable energy at the rumen level and absorbed nitrogen in relation to potential milk nitrogen yield. This effect was demonstrated recently in spring calving cows grazing grass/-white clover swards with minimal or no concentrate supplementation (Hameleers and Roberts 1994). As the clover content, and hence the dietary protein intake, increased in the sward during the season the urinary nitrogen content of the cows also increased by over 50%. (Table 3). Producers who adopt low input clover based grazing systems could in fact be exacerbating nitrogen losses to the environment rather than reducing them as intended. In this case the dilution of the dietary nitrogen by a carbohydrate source could be considered as part of the system management.

Table 3 Milk and urine nitrogen levels in spring calving cows grazing a clover rich sward

Period	1	2
Sward clover content (g/kg DM)	91 .o	466.0
Sward N content (g/kg DM)	24.5	31.5
Milk yield (kg/day)	20.29	19.75
Milk N (g N/day)	107.9	109.6
Milk NPN (G N/day)	5.13	11.05
Urine total N (g/l)	3.85	5.91
Urine Urea N (g/l)	2.37	5.03

Period 1 - 19 May
Period 2 - 21 July

The commercial potential of clover based dairy systems has been clearly demonstrated in a long term study at the Crichton Royal Farm which has compared the financial and physical performance of two dairy herds. One herd was managed on a low input grass/clover system and the other herd managed in a conventional system. (Table 4).

This work has been taken out onto commercial dairy farms at a range of sites throughout England, sponsored by the MMB (Bax and Browne 1993) and the project has demonstrated the applicability of clover in a variety of dairy management systems. This will be described in more detail by Downes and Bax (1995). However, because milk production is an inherently inefficient process, with typically only 15% of nitrogen inputs convet-ted into milk, it may be more appropriate to follow an alternative route. Increased individual milk yields will reduce the total maintenance requirement. Reducing the stocking rate will reduce nitrogen losses from the soil. It would also permit a reduced level of inorganic nitrogen fertiliser use whilst still maintaining sufficient supplies of high quality grazing and winter forage and provide more

Table 4 Comparison of a grass/white clover system at two levels of intensity with a grass/nitrogen system

	Grass/white clover		Grass/nitrogen	
	Year 1	Year 2	Year 1	Year 2
Land area (ha)	46	46	36	36
Cow nos	70	70	70	70
Milk quota (l)	400,000	350,000	400,000	400,000
Milk sales (l/cow)	5719	5294	5724	5941
Conc use (kg/cow)	1096	501	1101	1077
Milk N/waste N	0.272	0.233	0.2250	0.229
Waste N (kg/ha/annum)	227	223	283	296

opportunities to control nitrate losses compared to clover rich swards. Such a system based on these principles has recently been established at the Crichton Royal Farm and is being compared to a low input clover based system which is perceived as an environmentally favourable and sustainable method of producing milk (See Table 5).

The potential for integrating species rich pasture into extensive strategies of dairying is also being investigated, with the aims of further increasing biodiversity within a commercially viable dairy system. The outcome of these projects will help milk producers to decide on the most appropriate way to develop their production system to meet future requirements.

Table 5 Alternative systems for extensive milk production

	Clover system	Low N system
Cow Nos	70	70
Land area (ha)	46	46
Target milk sales (l/cow)	5000	8000
Target concentrate use (kg/cow)	< 500	> 1500
Inorganic N use (kg/ha/year)	0	225

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More efficient use of manure and nutrients on dairy farms in France

A. Pflimlin, A. Le Gall, A. Farruggia,
S. Hacala (Institut de l'Elevage - Paris, France)

Abstract

Dairy farms in the Western part of France are less intensive than in the Netherlands. However, there is still a large diversity between farms with regards to stocking rate, fertilizer and concentrate inputs, grazing versus maize feeding, slurry or farm yard manure handling and finally nutrient balances.
Special attention is paid to the grass and maize rotation in relation to farm manure use. Model calculations and pilot farms show that economically efficient and environmentally friendly dairy systems can be achieved for a wide range of stocking rates and milk production per cow.

1 Introduction

Compared to the Netherlands, France is a low intensive livestock country. Taking away the non productive areas, the territory can be divided into three equal parts: arable land, grassland and forage crops, forest.
With about 15 million hectares of grass and forrage crops and 17 million livestock units, the average stocking rate is below 1,2 LSU/ha. This stocking rate decreases from 1,8 in the North West with mainly dairy farms and forage crops to 1,2 in the grassland areas around the Massif Central with mainly suckling cows and just below 0,8 in the South East with extensive sheep farming.
Moreover, about two thirds of the livestock farms grow part of their cereals for grain and straw. This gives them less input in concentrates and storage facilities and more land for spreading their manure.
After this rather general picture of the whole country we will discuss more specific problems in the West where not only half of the dairy cows and 2/3 of the beef bulls are located but also 2/3 of the pigs and poultry. Moreover, the soils are shallow and sensitive to nitrate leaching

2 A large diversity of dairy systems in the West

Brittany has a few points in common with the Netherlands especially with regards to manure and water quality. With about the same sutface area and a high stocking rate the quantity of manure was not limited by the milk quota: the reduction in the number of cows is more than compensated for by the increase of beef bulls, pigs and chicken. At the same time mineral fertilizer was still increasing even if nitrogen stays below 100 total N per ha (Table 1). Perennial rye grass and maize are the two main forage crops.
By contrast, Normandy is still a predominantly cattle region; the amount of livestock hasn't increased and the amount of fertilizer used is low. Moreover, permanent grassland covers more than 60% and maize less than 15% of the total area. Nevertheless, in spite of the low stocking rate and no real excess of animal waste, local water pollution problems do exist and have to be

Table 1 **N** inputs/hectare in Brittany and Normandy

	Brittany			Normandy		
	Animal wastes[1]	Mineral N	Total	Animal wastes[1]	Mineral N	Total
1973		65		71	30	101
1988	100	84	264	74	56	130
1993	130[2]	93		74[3]	67	161

[1] 73 N X LSU/ha
[2] 60% from cattle
[3] 90% from cattle

Table 2 Main dairy systems in Pays de Loire (pilot farms equalized to a same milk quota (210,000 l.) and 1.5 family workers)

	Intensive milk + beefbull	Intensive milk + cereals	Milk and steers	Low input dairy system
Yield/cow	7 000	7 000	6 000	5 000
Number of cows	30	30	35	42
Other LSU (males heifers)	22	10	35	14
Stocking rate/ha forage	1.8	2	1.55	1.25
Total ha forage	26	22	45	45
Ha maize (+ cereals)	13 (+4)	11 (+13)	8 (+0)	0 (+0)
Total ha (forage +crop)	30	35	45	45
Organic N/ha (kg)	125	85	110	90
N exces/ha (kg)	195	170	120	75

improved by intensive advisory schemes.

In the Pays de Loire, cattle are also predominant but they are raised on forage crops such as maize, Italian rye grass as a catch crop and temporaty leys for 3 or 4 years, of perennial rye grass or orchard grass. After 4 years of grassland, maize will be grown for 2 or 3 years and will receive most of the cattle manure. When straw and concentrates are purchased, the soil will receive large amounts of organic matter, also as mineral nutrients which can cause problems for the ground water...

In Table 2 there is a short summary of the main dairy systems on the pilot farms in this region. Each of the four prototypes is very similar to a group of real farms but with the same milk quota. The income and the amount of labour are about the same for all four. As land is available at a moderate price (about 200-250 Gulden/ha rented) the same level of income can be achieved in several ways:

- Milk production from 5 to 7 000 liters
- 400 to 1 900 kg concentrates per cow
- Maize silage from none to 50% of the total forage area
- Catch crop from none to 25%.

Thus, stocking rate will range from 1,2 on a low input grassland system to 2 livestock units (LSU)

Table 3 Main farm characteristics and nitrogen balance on a farm scale in France

Region	**Brittany**	**Pays de Loire**	**Normandy**
Milk production:			
1 (ha FA) year	7900	7060	5570
1 cow year	5810	6060	5580
Stocking rates (units ha)	1.91	1.65	1.49
Total surface			
% Perm. grassland	0	1	50
% Temp. grassland	51	46	12
% Silage maize	38	40	24
% Cereals	10	13	13
N Balance (kg ha - year)			
Inputs			
Fertilizers	200	198	119
Concentrates	64	79	41
N2 fixation	0	0	7
Others	3	4	2
outputs			
Crops	6	8	9
Milk	47	40	27
Meat	8	8	5
Inputs - outputs (± SD)	206 (± 55)	225 (± 90)	128 (± 56)

on a dairy and beef bullock system. Nitrogen balance will vary at the same time from 75 units (including 40 N from white clover) to 200 N in the dairy + beef bullock system (Institut de l'Elevage and al., 1994).

These N balances have not been reached yet by the average dairy farm in Brittany or in Pays de Loire as shown in Table 3 where the N surplus is around 200 N. But this is well below the surplus mentioned by Aarts et al, (1988) for the Netherlands or Werbruggen et al (1994) for Belgium.

For French dairy farms there is still the prospect of improving the nutrient balance without jeopardizing the stocking rate too much:

- the excess of N is about same as the the amount of purchased mineral N
- the relationship between stocking rate and N excess is pretty weak and the range very wide (for example an excess of 100 to 400 N for a stocking rate of 2 cows/hectare).

Moreover, with such a large diversity of forage systems, a nitrogen balance below 150 N will probably be a pretty poor criteria for estimating the real nitrogen losses. A 100 N excess in a 50% grass and maize system with Farm Yard Manure (FYM) is probably not safe for the 50 mg nitrate limit for drinking water for several reasons:

- After ploughing, grassland will release up to two hundred units of N during the first few years, and part of it will be left in autumn when the maize crop is harvested.
- The same is likely with Farm Yard Manure (FYM) which will release only 20% of total N for the maize. But mineralization will continue during autumn and winter in the West of France.
- As maize takes up nitrogen during only 2 or 3 months a year, the risks for leaching are maximum with this type of forage, which would justify a catch crop sown in early summer.

As an example of these sorts of difficulties we can mention a pilot advisory experience lasting for 5 years without significant results. Despite a real decrease in the amount of fertilizer for the maize, (no mineral fet-tilizer and moderate amount of FYM), nitrate in the river (close to 50 mg $N0_3$) did not decrease during the last few years.

3 - Research and Development on farm manure and nutrient budgets on dairy farms

EU and French regulations on water quality and nitrate levels contain some new restrictions on housing, animal waste storage and rules for good practice when using manure.

Big changes will have to happen on most of the dairy farms and we will need new methods and new information to provide adequate advice for each farm.

We already have a proven method for a diagnosis which scales up the pollution risks from the stable to the fields. We can also propose types of systems where advisers can recognise similarities to the farm they are dealing with.

So, there are still two points left to get this new advisory service working :

1 The training of a new generation of advisers who will have to know quite a few things about a very large range of subjects, from housing to agronomy, as well as animal and human welfare. That advocates for more good experienced generalists.

2 The information for optimum advice. We will stress the second point a bit more indicating the main aspects we are working on.

Combine field observation, model calculations and experimental work

We have already shown that dairy farms in the West have very varied systems with more or less maize, long or short grass leys, slurry or farm yard manure. Even with a stocking rate below 2 cows per hectare and N surplus below 150, there can be too much nitrate leaching through the soil for safe drinking water.

To investigate the differents points of the whole N P and K cycles we set up two simular farmlets in two different regions:

- In South West France comparing systems with 40% and 100% of maize,
- In Brittany comparing systems with 15% and 40% of maize and the rest as perenial rye grass.

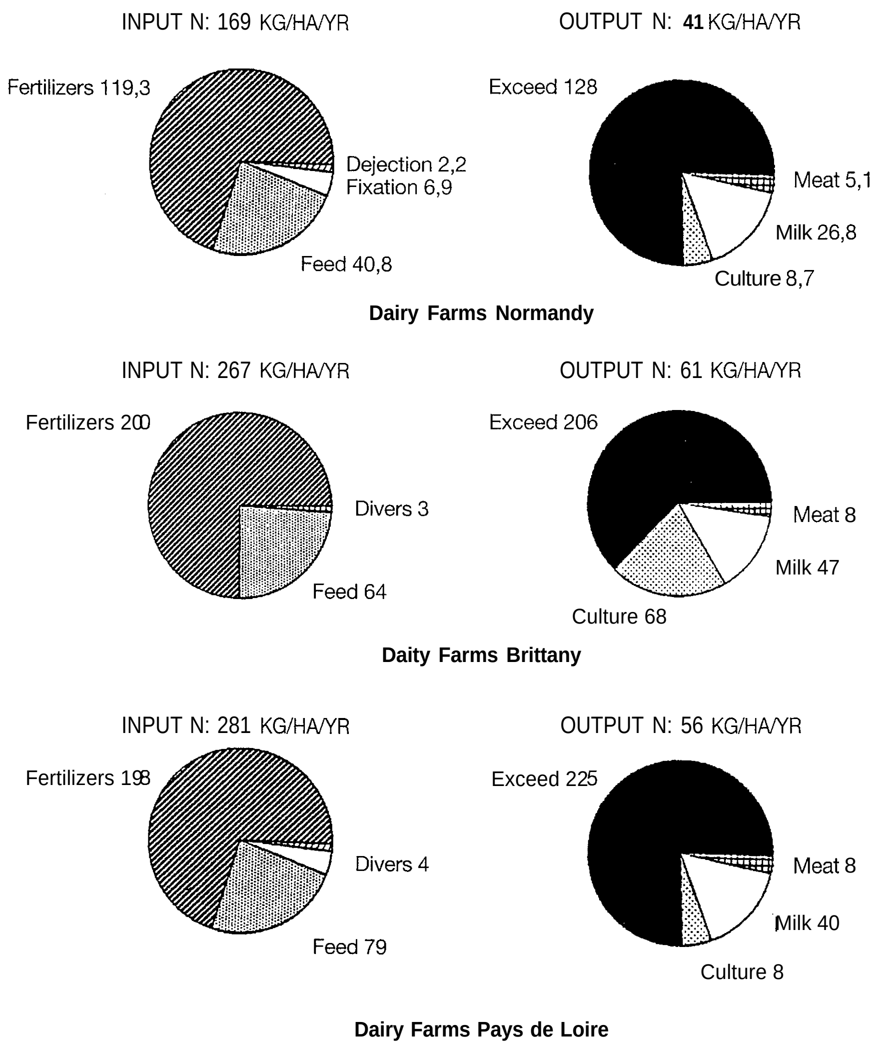
Model calculations were made previously to define the system to be compared and the nutrient losses expected. Controls will be made on animal intake and production, animal waste, manure storage, handling and spreading, forage production and nutrient losses, especially nitrate, to the soil and ground water. Initial results will be available for the Symposium

More efficient use of farm manure

In most of the well-managed dairy systems, farm manure should cover P and K for forage production. Even N should be self-sufficient with grass clover swards. But the facts are quite different today because most of the farmers do not believe they can have a precise fertilizer programme with only farm manure. We have to recognize that research and development have to do more work on several aspects:

1. To characterize the different organic fertilizers produced on the farm. Slurry can be more or less diluted by rain or dirty water; solid manure can be made with 2 to 10 kg straw per cow and day. Density will also vary a lot. Dry matter and nutrient content will also vary during storage etc... So we need easy to manage equipment for the farmer to be able to analyse his manure (Hacala and al., 1994).
2. To control the amount of manure put on the field. Here again there is a large gap between the quantity that the farmer expected to spread and the true value controlled.
3. The direct fertilizer value, especially the nitrogen fraction, available for grass or maize depends largely on the time of application and the way of spreading.
4. Comparing N losses between slurry, farm yard manure or compost, from the stable to the field. It will probably take years to get accurate figures for the main dairy systems in France. One or several European program-

Figure 1 Input and output nitrogen (kg N/ha) on dairy farms)



mes would be welcome on this topic.

5 Specific studies on composting solide manure. As straw bedding is still very common in France composting can be a good way of handling manure : no smell, less quantities, less nitrate leaching etc . . . . Studies are starting on bacteriological aspects (Salmonella, Listeria) in case of spreading on grazed fields. Some French farmers seem to be very enthusiastic about this technigue and will work together with the same equipment.

4 Conclusions

This is quite a long list of studies going on or just starting and it will take time before we will have most of the answers. But environmental pressure is strong and things are changing quickly especially for dairy farmers. Today R and D partners are working well together even if the amount of research is still small with respect to the environmental challenge. More collaboration between our countries would be welcome in order to change the negative consumer image of intensive livestock systems.

If the goals are the same, the ways of achieving them can be different for each country. In France about half of the dairy farms are still located on permanent grassland areas including mountains where a large part of the milk is converted into high quality cheese. The West has less specific dairy products and is more open to the European market. Nevertheless, even there we can already show some economically efficient and environmentally friendly dairy farms within a wide range of milk yield per cow and stocking rate:

- with home grown forage and cereals
- more or less grazing or maize feeding with little purchased fertilizers and concentrates.

Water quality is still the main environmental issue. As well as using nutrients from farm manure more efficiently, the reducing of ammonia losses to the air will be a problem in the future, even if there are no specific regulations in France yet.

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Nature and landscape issues in Germany

M. Elsässer- (Staatliche Lehr- und Versuchsanstalt für Viehhaltung und Grünlandwirtschaft- Aulendorf, Germany)

Abstract

Since the reform of the EU agrarian policy in 1992, the demands of an increasingly more aware society and the negative effects of high fertilization and high stocking rates, limit the dairy production at high intensity level throughout Europe. Following well-known economic rules, the farmers until now have been anxious to increase the intensity of milk production, in order to stabilize their personal income. The existing laws and decrees for environmental protection and extensification in order to reduce the surpluses in food production have opposing objectives. This explains the need and intention of supplementary governmental programmes which stimulate extensive production through direct income payment in order to provide special protection of natural resources and landscape.

Some programmes in Germany have offered the possibility of additional payment for special ecological performance. Examples are given of Baden-Wütttemberg (South Germany) with the water protection decree (SchALVO) and the MEKA (the programme for market discharge and preservation of landscape).

1. The current situation

Until the reform of EU agrarian policy in 1992, the subsidies for the farmers were closely related to yield produced in agriculture. This resulted in an increased production in order to stabilize the farm incomes followed by a steady surplus in food production. The new policy, with the drop of product prices to the level of the world market, forces the farmers to use production methods more efficiently.

On the other hand, agricultural statistics demonstrate a high nitrogen surplus owing to intensive grassland management followed by nitrate problems in drinking water (Aarts et al., 1992; Isermann, 1991). In addition, certain environmental protection organizations in Germany are complaining about the decreasing biodiversity owing to intensive grassland management. Stemming from this, new objectives for grassland and daity production gain higher priority farmers are now becoming more aware at. Such issues as sustainable production, avoiding nitrogen surplus, high biodiversity with special protection of birds and other animals in ecosytems and the maintenance of rural areas as being part of the national heritage consequently, new systems for grassland management need to be developed.

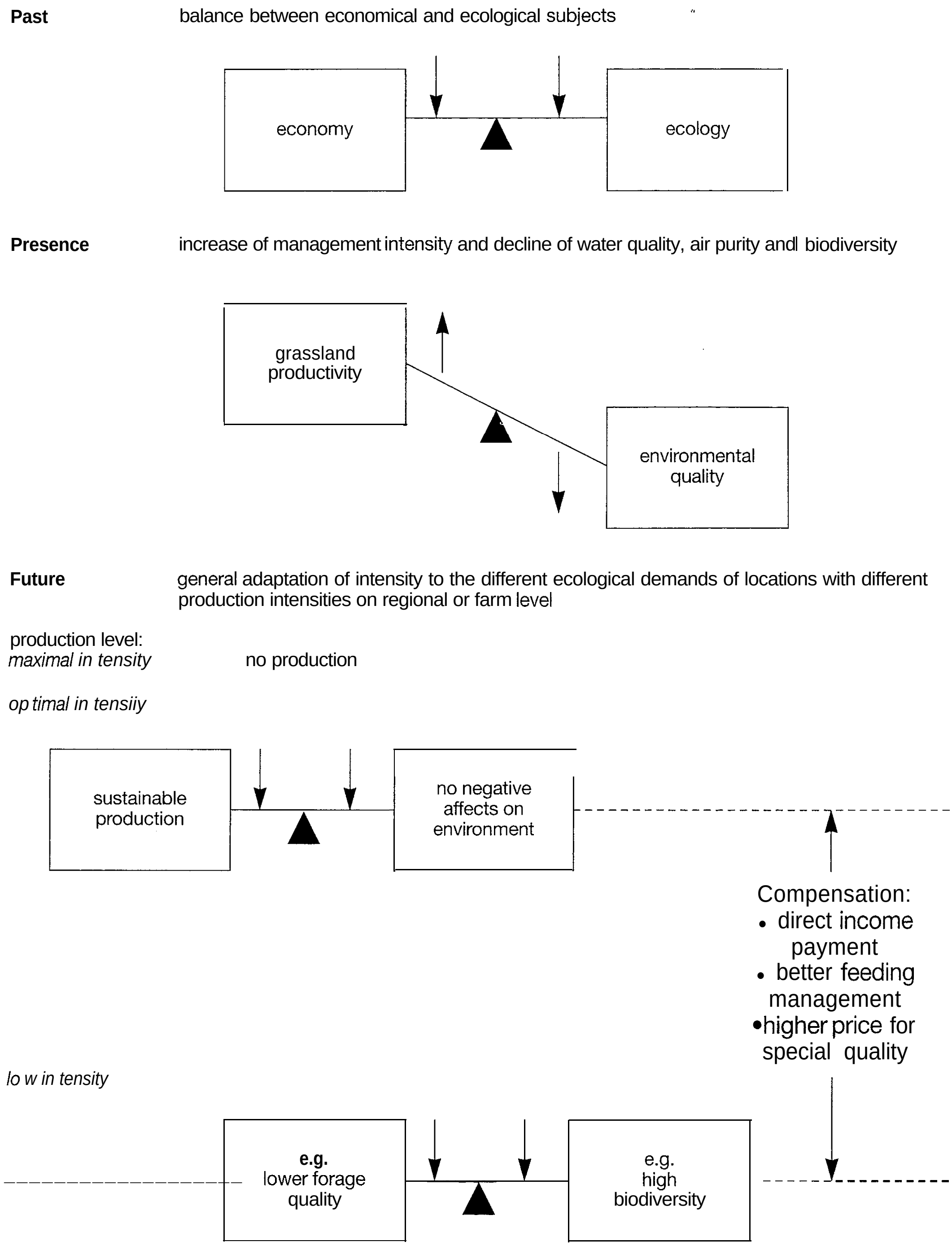
2. Adequate farmer incomes, a prerequisite for economic sustainability

In the past, when the average farm size was small, the normally extensive production systems fulfilled both the nature protecting targets on the one hand and the economic objectives on the other hand (Figure 1). Since the Seventies and Eighties, the utilization intensity increased and generated a higher income for the farmers. Consequently, the very high intensity in grassland management in parts of Europe has reached ecological limits and a new awareness is developing in society. Both processes force the farmers to look for new production methods and it is no longer possible for a increase in production to be the only possibility for stabilizing the personal income of the farmer. Different governmental programmes are necessary in order to allow farmers to earn an adequate income for the preparation of “public goods” such as landscape and nature.

3. Different programmes help the farmers achieve a stable income

In order to solve these conflicts different ways are possible in the future. First the increase in production efficiency, e.g. an increase in milk performance per cow with a higher support of concentrates or a better use of nitrogen, should be realized. However, the higher concentration of nutrients in the manure reaches the ecological limits in view of the return of organic fertilizers to the field. Therefore, the level of production intensity has to decrease in order to fulfil the ecological requirements, but this in turn lowers

Figure 1 Development of production intensity on grassland and its effects on economical and ecological situation of the farms and'landscape



the farmers income. The difference has to be compensated for by direct income payments, not as a subsidy, but as a payment for the production of a healthy environment. Therefore, the increased efficiency of fertilized nutrients, for instance, or the adaptation of stocking rates according to the ecological situation of different regions and grassland sites in Germany are being discussed. Therefore, it is necessary to define the possible intensification of different sites and the suitable production methods in terms of the site attributes.

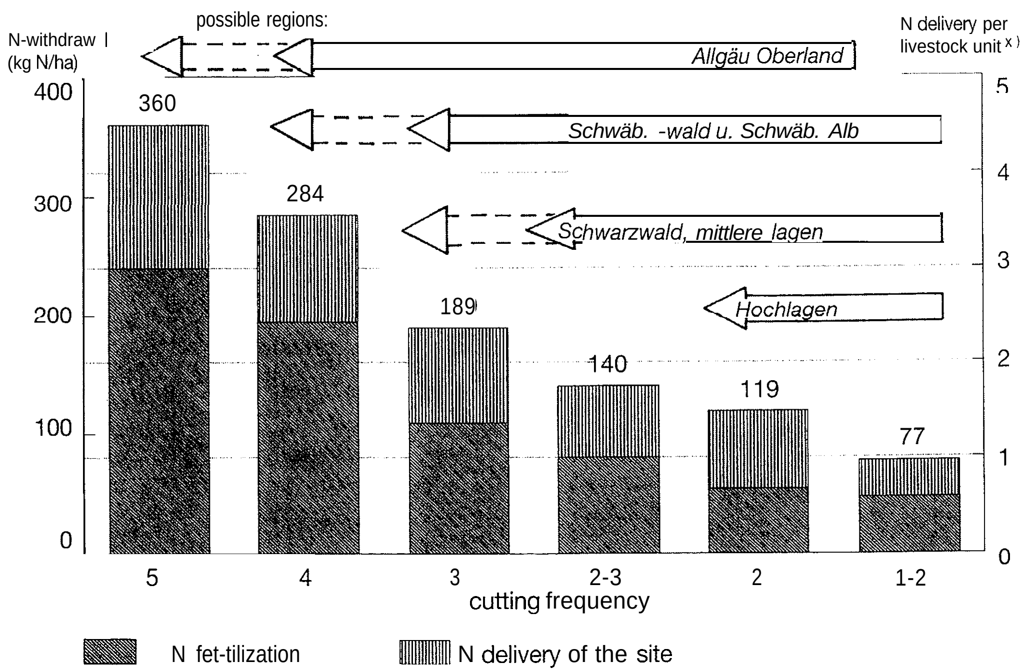
3.7 *The decree for* water *protection and direct income payment (SchALVO)*

The adaptation of utilization and the potential intensity at different sites has been realized for Baden-Wuerttemberg with the SchALVO (1987), the decree for water protection areas which demands a 20% reduction of the amount of nitrogen of the so called "duly" fertilization. The duly fertilization takes the average N-delivery of the site into account (Elsaesser, 1994). According to this definition, the limiting factor for high utilization intensity is the area available for placing animal manure. Stocking rate and utilization potential of grassland have to be closely related to the ecological attributes of the site. Figure 2 describes this relationship with examples from Baden-Wütttemberg. According to this, a maximal stocking rate of 1 .O Lifestock unit (L.U.) is suitable on mountain areas, whereas 2.5 L.U. are still possible on sites with a high yield potential like the Allgäu. This shows that on unfavourable sites the stocking rate has to be low. As a consequence of the SchALVO, grassland yield decreases steadily and the farmers get a direct payment of 310 DM per ha. The programme has been successful until now, because the nitrate contents in the soil have decreased. On the other hand, the possibilities for the future development of dairy farms are rather low in water protection areas and closely related to the possibiiities for an enlargement of the farm area suitable for the return of animal manure.

3.2 *The programme for market discharge and preservation of landscape (MEKA)*

In the last five years, German society has become aware, that without the work of the farmers, the cultural landscape can not be maintained. Therefore, the landscape and the traditional, more or less extensive production

Figure 2 Possible utilization intensity and N fertilization in Baden-Wuerttemberg



x) 1 livestock unit = 22m³ slurry/a = 80 kg/a systems are to be preserved. This is being achieved through certain programmes in Germany linking the two objectives -lower production and landscape maintenance. Such programmes exist in different forms in some states of Germany. In Baden-Wuerttemberg for instance, the programme is entitled MEKA (= programme for market discharge and preservation of landscape) and is notified of the EU. It is subdivided into 3 main patts.

part 7: promotes the utilization of land as grassland in sensitive areas for soil protection and the maintenance of the cultural landscape;

part 2: secures endangered utilization systems with special performances for landscape maintenance;

part 3: promotes extensive and ecological plant production.

The different performances of the farmers are rated on a pointsscale, of which each point has a value of 20 DM/ha. Different stocking rates give a different number of points. E.g. a stocking rate of less than 1.2 lifestock units (L.U.)/ha gives 5 points. More than 1.8 L.U. has a value of only 2 points/ha. Fees are paid for the maintenance of grassland utilization of steep slopes in mountain areas, for flower - rich meadows, for extensive orchards and the breeding of typical cattle species. The participation in the programme is voluntaty and reversible after 5 years.

The MEKA programme leads to the agricultural production and the maintenance of cultural landscape in unfavourable areas and move ecological production methods in whole regions.

4. **Summaty**

In Germany, a number of different governmental programmes exist which link economy and ecology. They limit intensive grassland production by restricting stocking-rates, times for the fettilization of manure and maximum amounts of fertilizer. They aim at compensating for the losses in farm income, owing to the more ecological production, by direct payment. Nevertheless, all existing programmes cannot avoid the fact that the farmer's income will decrease, if the production volume cannot be enlarged.

The production intensity in future has to be adapted to the productivity and the ecological possibilities of each site. This leads to a certain extensification, whereas the decrease in intensity can happen at farm or regional level. In spite of these programmes, the change in milk quotas from disadvantaged regions in high production areas with maize cultivation can probably not be prevented. Big farms or farm cooperatives have the chance to survive, if they are able to lower their production costs.

The use of extensive forage is possible and profitable up to a portion of 20 % of the fodder fed to heifers and cows in the late lactation period. By using the best feeding management practices on daity farms with separation of the cows into different performance groups, the use of maximum 40 % of extensive forage could possibly be achieved.

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Indicators to describe sustainability in dairy farming

V. Østergaard (Research Centre-Foulum, Denmark)

Abstract

Indicators are necessary for the assessment of the sustainability of agricultural production, in for example daity farming systems. These indicators should have the following features: a) be representative for the chosen system and have a scientific basis, b) be quantifiable, c) be part of the cause-effect chain and d) offer implications for policy making.

The formulation or definition of the indicators starts by setting goals for ecological, economic and social sustainability. These goals are divided into a number of objectives. Causal factors of each objective are chosen and divided until the last ones can be described as indicators with the above mentioned features.

1 Introduction

The United Nations Conference on the Environment and Development of 1992 (Agenda 21, 1992) emphasised the fact that national agricultural systems in general use and under development may not be sustainable, since they are depleting the natural resource base and imposing high environmental costs to the system. Therefore, it is necessary for both international and national agricultural research institutes to develop technology (systems and knowledge) that is sustainable from both an economic, ecological and social point of view. Denmark is also involved in this task, for example by setting up different projects such as Strategies for Sustainable Agriculture and Organic Farming.

Indicators, which can be used both for the description and evaluation of sustainability within a certain ecosystem are needed for the development of sustainable daity farming systems. The paper will discuss the characteristics of indicators, methods of indicator formulation and indicators to describe sustainability.

2 Characteristics of indicators

The definition of the term "indicator" used is that of Vos et al. Gilbert and Feenstra have used the same definition namely, "In measurement theory the term "indicator" is used for the empirical specification of concepts that cannot be (fully) operationalized on the basis of generally accepted rules".

The indicators may be used for problem identification, planning, monitoring, allocation of socio-economie resources and policy assessment, amongst other things. In this case however, the primaty purpose of indicators is to evaluate the livestock farming system, that is assessment of sustainability. It should be emphasised that the important relationship with scale, that is farm, community, region etc, is not discussed in this paper even though it is very important.

Gilbert and Feenstra have identified four desired features of indicators on the basis of literature research:

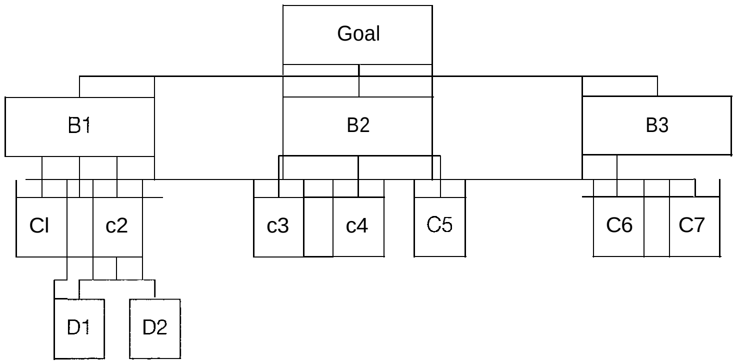
a. The indicator must be representative for the system chosen and must have a scientific basis.
b. Indicators must be quantifiable.
c. A part of the cause-effect chain should be clearly represented by the indicator.
d. Indicator should offer implications for policy.

3 Method of indicator formulation

The formulation of indicators should be made using a method resulting in the above mentioned four features. The reason being that it is necessaty to document and communicate the research method and results. A method to describe goals by objectives and indicators is formulated by Vemuri.

This method starts with the goal of the decision-maker. In order to measure how well this goal is fulfilled, it is often necessaty to divide the goal into a number of objectives, central to fulfilling the goal. These objectives (Bl, B2, in Figure 1) can further be divided into causal factors (Cl, C2,) and finally into indicators (Dl, D2,), which can be measured

Figure 1 Model to describe a goal using objectives. causal factors and indicators. Schematically (Mod. a. Vemuri, 1978)



and are quantifiable (see above), as shown schematically in Figure 1. A few examples focusing on ecological sustainability are given below, although economic and social sustainability are of similar impot-tance.

4 indicators to evaluate the sustainability of dairy farming systems

4.1 *The concept of sustainability*

It can be stated that the concept of sustainability (= sustainable development) can be looked at from a political, administrative or scientific point of view. Different views on the concept are observed in the politica1 discussion. However such views are undoubtly developed by politica1 bias and/or insufficient knowledge about important biological or economic relationships within the various levels, from the field and farm level to the national, regional or global level.

Despite the above statement, it might be assumed that all the actors - primary actors such as farmers and family members, secondary actors such as advisers and users of nature, as well as tertiary actors such as politicians and consumers - can place their goals and objectives within the three main goals of sustainable development, that is ecological, economic and social sustainability. The aim of the present study is a scientific evaluation of the sustainability of the livestock farm as a component of an ecosystem. Therefore there must be a scientific selection of the indicators, that is by using the method described and by ensuring that the indicators include the above mentioned four features.

4.2 *Ecological sustainability*

The Brundtland report, “Our Common Future” underlines the fact that sustainable development also requires a production system, which respects the commitment to preserve the ecological basis for development. In other words flora, fauna, soil, water and the climate within the biological environment must not be diminished for future generations.

According to the review paper by Yunlong and Smit, the ecological definition of sustainability focuses on biophysical processes and the continued productivity and functioning of ecosystems. Long term ecological sustainability requires the maintenance of the resource base quality, and eventually its productivity, especially the sustained yield of the land. Ecological sustainability also demands the preservation of physical conditions, especially the hydrology of surface water, ground water and the climate. Protection of genetic resources and the conservation of biological diversity are other matters of importance. Below, just a few examples of indicators related to mixed crop dairy farming are given.

Biological diversity

The objective of biodiversity, or biological variation and quantity, is a necessity for the ability of future generations to fulfill their need for livestock - seen from a quality and quantity point of view.

The fulfilment of the objective depends on:

a. Number of species and breeds of livestock.
b. Flora and fauna, wealth of species, exemplified by further causal factors such as biotopes, permanent pastures, windbreaks etc.
c. Composition of crops within cultivated land.

Examples of indicators for biodiversity are the number of breeds and population size within breeds, acreage for pasture, number of small biotopes and links between these, as well as total acreage, acreage and length of windbreaks and acreage of various crops within the cultivated land.

Fertile soil

Fulfillment of the objective to maintain or develop fertile soil depends on the level of erosion, the amount of organic matter, biomass and nutrients (e.g. N, P and K) in the soil, as well as the possible accumulation of pesticides and unwanted minerals.

Erosion depends on the choice of crops, the use of windbreaks, tillage, and mechanization. Indicators can be number and type of crops, total acreage, length and acreage of windbreaks, number and type of tillage (treatments), etc. Figure 2 shows one goal and examples of objectives, causal factors and related indicators.

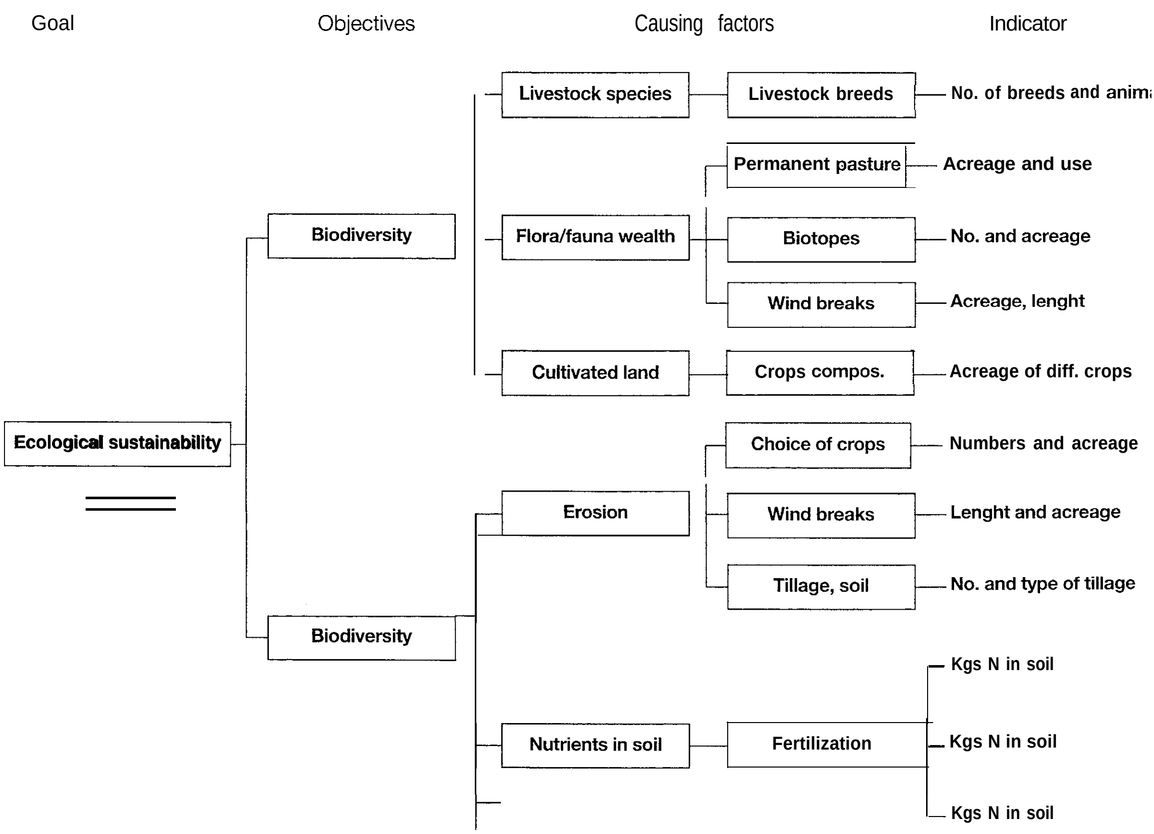
Other objectives

Other objectives of ecological sustainability can be:

- reduced unrenewable resource use by the use of biogas and windmills,
- pure ground water,
- pure streams, rivers and lakes,
- pure oceans and pure air.

These objectives are influenced by factors which have related indicators. These indicators

Figure 2 Goal, objectives, causing factors and indicator, examples



can be measured and quantified in a similar way to the indicators mentioned above.

4.3 *Economic sustainability*

Several objectives can be included within the goal of economic sustainability, such as:

- comparable income,
- income stability,
- high production per unit of input.

The description of causal factors and the related indicators is similar to that of ecological sustainability.

4.4 *Social sus tainability*

The third goal, social sustainability, includes several objectives for the fulfilment of human welfare, among others:

- amount and profile of labour input,
- healthy working environment,
- sparring partners
- spare time for sport and cultural activities.

The description of the causal factors and the related indicators should be made by means of the same method used above. More details are given by Ostergaard and Hansen.

5 Conclusion

Indicators are required for the assessment of sustainability of agricultural production, such as livestock farming systems. It is important that the sustainability of livestock farming should be described as soon as possible - also by means of livestock systems research. In order to identify and formulate research issues, it is necessary to be aware of how to identify appropriate indicators and how to measure and assess the sustainability of different production systems. By repeating this assessment in the future, it will be possible to avoid repeating some of the mistakes that have already been made within the western world.

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Dairy farming in relation to nature and landscape: a typical north german farm

Mrs. H. Möllgaard (farmer from Tinningstedt, Germany)

1 Introduction

My parent's farm, which is presented here, is a typical Schleswig-Holstein dairy farm. As far as environmental aspects are concerned there has been an adjustment in farming in accordance with the legal and economic requirement. Following a description of the farm, the changing conditions and the adaptions will be discussed. Thoughts about possible developments in the future will conclude this paper.

To give a better picture of the farm data in comparison to other Schleswig-Holstein farms, I used the yearly publication ("Rinderreport") of the agricultural advisory association. Data from 16% of the farms and 21% of the cows are registered by agricultural advisors before they are processed and compiled into this publication. This farm joined the association in 1974 and so most of the data come from there.

2 Farm situation

2.1 *Land*

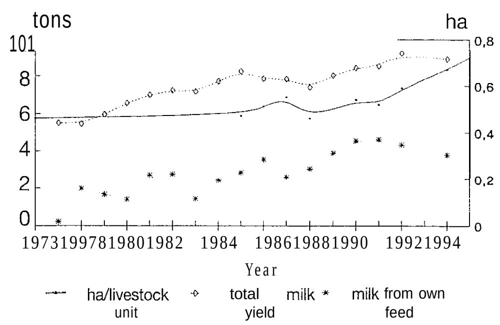
Total: 90 ha

Netto: 85 ha	75 ha grassland
	10 ha maize
stocking rate:	1.29 live-stock units/hectare

Most of the land is light and sandy. 28 ha of the farm's land is heavier marshy soil since the farm is located 20 km from the North Sea on the edge of old marshland. Most of the pastures are mown one to three times a year to produce silage, and cattle graze on them for the rest of the time. 10 ha corn is grown to make maize silage, mainly to feed the cows.

In the last twenty years the farm has grown steadily from 45 ha to it's present size. Most of it has been grassland, except for some turnips, some rye and a little bit of wheat on the heavier soils in the seventies. Corn has been grown since 1980.

Figure 3 Milk yield and stocking rate



Stocking rate

year:	lsu/ha:
1973	0.46
1988	0.47
1985	0.51
1986	0.46
1990	0.54
1992	0.59
1994	0.67
1995	>0.72

The stocking rate increased since we had to take along some land with the additional milkquota we leased. Since last year we pat-ticipate in an extensification programme which is described lateron.

2.2 Cattle

Total:	110 live
stock units	64 cows
	50 female calves (<1 year)
	48 heifers (1-2 years)
	6 males

Because of the housing system mostly slurty is produced. The little calves produce some dung.

Figure 1 Fertilization grassilage

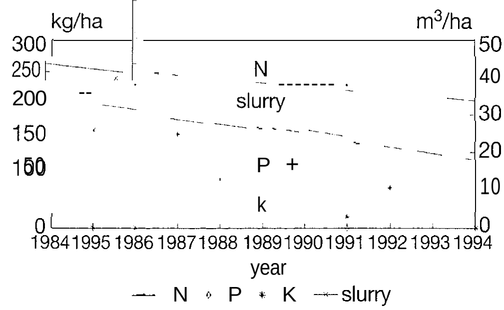
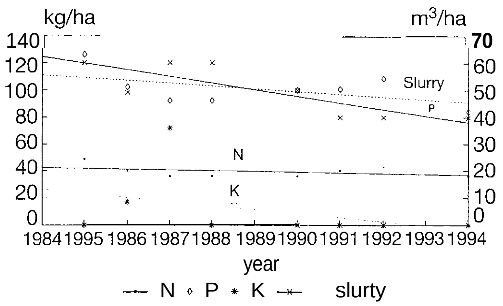


Figure 2 Fertilization maize



2.3 Milk Production

quota:	**565 000** kg
average /cow/year:	
	8900 kg milk
	3800 kg (from home-grown-forage)
ha/cow:	0.74

The yield-level for milk is above the average in Schleswig-Holstein as well as the number of cows per hectare. This indicates a high intensity of the milk production.

The milk yield has grown (the total as well as the performance from the home-grown-forage). There are fluctuations within the curves because of different qualities of feed. There is no connection between the performance and the stocking rate.

The average milk yield of cows published in the "Rinderreport 1994" was 6300 kg, 2900 kg out of home-grown forage. The average farm had 50 cows.

2.4 *Fertilization*

Every three years the soil is examined for phosphorus, potassium, magnesium and the need for lime, so that the fertilizers and the manure can be applied according to the official agricultural recommendations.

Grassland

In 1994, 180 to 210 kg N and 75 kg P/ha were applied in mineral fertilizers. In addition 20m^3 slurry were applied per hectare.

The next diagram "fertilization grass silage" (cutting twice and grazing afterwards) shows the trend in fertilization over the last years. It is obvious that the input has decreased bearing in mind that fewer animals have to live on one hectare.

Maize

Last year the corn received 36 kg N, 84 kg P and 40m^3 slurry. Over the years we have found a lower input of mineral phosphorus and potassium. The application of mineral N has been stable at around 40 kg. Slurry application has decreased a little. The average amounts for comparable soils were 49 kg N, 83 kg P, 4 kg K and 27 m^3 slurry.

3 **Changing conditions for the farming**

3.1 *Land demand and fertilization*

In 1974, when my father joined the agricultural advisory association the main aim was to have many cows on little land and to increase milk production at the same time. This was achieved by feeding the cows up to 2.6 tons of concentrate a year.

The introduction of the milk quota meant that with higher milk yields the number of cows decreased. It became more important to improve production, e.g. by having a better quality of silage and consequently a better milk yield from home-grown forage. The amount of land and the number of cows were not the limiting factors any more, this was the quota. Therefore the intensification process of increased numbers of cows with relation to land of the seventies and early eighties was somewhat halted.

Owing to this situation, the state of Schleswig-Holstein offered a progamme for the cultivation of the landscape in the village where the farm is situated. The idea was to create ponds and other different, natural areas for all kinds of plant and animal species which would naturally live in these surroundings. They asked the farmers for land and set up these biotopes. A one hectare biotope with a 2000m^2 pond resulted from this. Before this it had been partly swamp and moor land. Another half a hectare was placed at the disposal of this programme.

Since 1993, these biotopes have been economically disadvantageous because they do not count as netto-area. Environmentally they are still positive and an enrichment to nature. Most of them situated in such a way that hardly any people come by to disturb the animals there.

In 1994, the state of Schleswig-Holstein offered an extensification programme for farmers with a minimum of 70% grassland who would commit themselves to keeping the pastures and holding no more than 1.4 live-stock units per hectare for five years. For this they get a certain amount of money per hectare in compensation.

To fulfill the conditions of this programme my parents bought 4.5 hectares of cheap land. The price for it was about a third of the payments the government would make over the five years.

Because of this programme there is so much land, that the percentage of high quality forage (first cut of gras for silage) will increase while the intensity of the use later in the year will decrease. This means that the fer-tilization in spring and early summer will be, as in the previous years, according to the requirements. On the other hand, no mineral fertilization after July will be necessaty. This makes the farming more positive from the environmental point of view.

More land and less cattle will also make it easier to match the regulations we expect for applying fertilizers. A law which regulates the handling of manure has existed since 1989. The maximum amount of slurry application per qear and hectare is 40 m^3. It is forbidden to apply slurry between the beginning of October and the beginning of February (grown land) or March (ungrown land).

4 Perspectives

It is important for the farmers that they can apply enough nutrients in spring to be able to harvest good quality silage in sufficient amounts off the first cut. This should be considered in the new regulation for fertilization, which is expected this or next year.

We want to bring more clover into our grass-swards which should be possible through a more extensive production. High clover portions help to lower mineral N fet-tilization.

The agricultural advisory association has published nutrient balances for the farms in the "Rinderreport" since 1993. According to these results, more successful farms have economically better nutrient balances. This aspect again leads to feeding practise. Improving the feeding of the cows, is and will be an important objective. First we have to determine their actual need more exactly and then find the best way to meet the need. We have to feed less concentrates and more single components in a economical way. Better feeding techniques increase the daily forage intake of the cows and milk yield can be influeced in this way.

The application method of slurry must be mentioned as well. Better techniques are more expensive yet environmentally friendly. The question of whether we will be able to save some mineral nutrients through better application methods must be answered in the future.

As already mentioned the aim is still to improve the milk production and increase the milk yield of a single cow so that we can lower the the input of energy, concentrates, mineral fertilizers and mineral supplements. Meanwhile the emission of methane is decreaseing reatively and less amounts of slurry will be produced. Thus we can in a more envoronmentally friendly and more economically under tougher conditions.

Experience of a commercial dairy farmer in the UK

J Downes (farmer from the Farm, Lognor - Scotland) and
J. A. Bax (Dumfries - Scotland)

Introduction

As a philosophy, low cost milk production has been promoted in the uk for many years. However, since the introduction of milk quotas in 1984 the low cost of concentrate feeds relative to the milk price has encouraged many producers to develop their businesses in the opposite direction. The economic and legislative climate is now stat-ting to alter again. On 1 november 1994 the uk milk processing industry was deregulated, which has led to a short term increase in the milk price, as the new purchasing companies compete for milk supplies. The price received for milk in february 1995 was 25-26 p/l. These prices are unlikely to be sustainable in the longer term and a more realistic figure of 20-21 p/l should be considered when planning business developments for the future. Downward pressure on milk prices will also arise from changes in the cap and the renegotiation of the gatt. There is also now an increasing requirement to invest additional capital in farm waste management measures to comply with new legislation. The opportunity to increase milk production to maintain profitability is limited by the cost of obtaining additional quota. An alternative is to reduce the costs of production, which is the strategy that we have followed since the introduction of milk quotas.

Development of a low cost dairy system

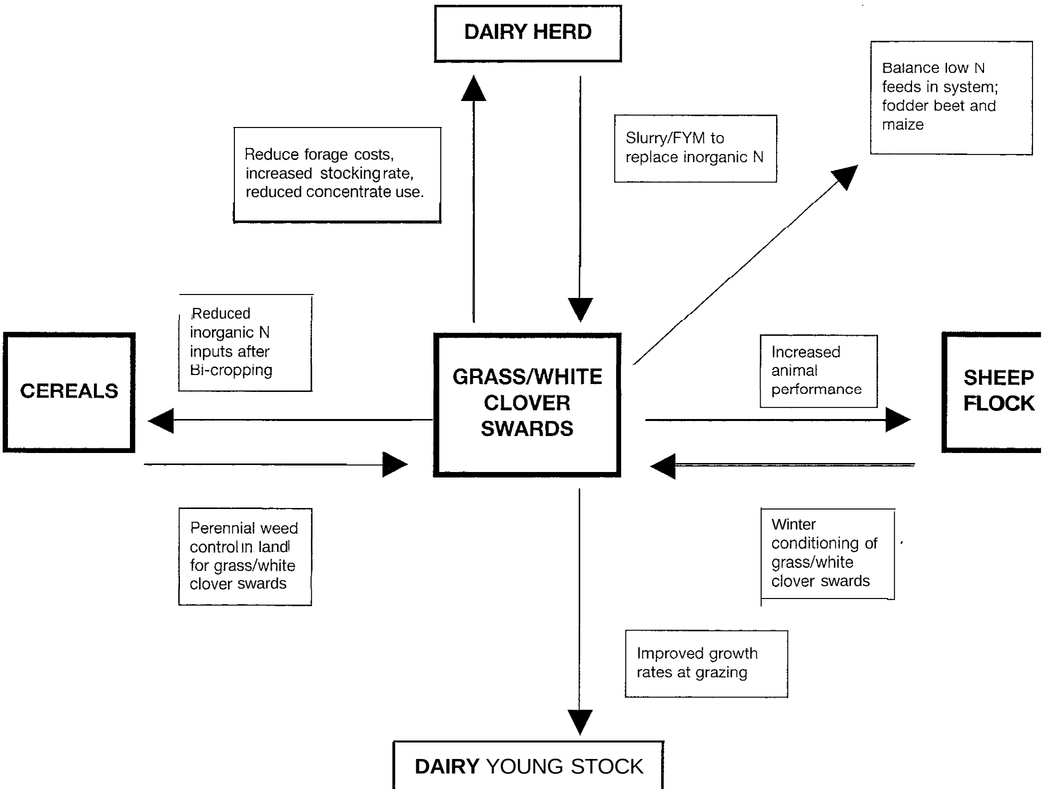
The farm is a 237 ha traditional mixed farming unit situated 12 km south of shrewsbury. It supports a dairy herd of 115 cows, 340 breeding ewes, finishes 60 beef cattle a year and has 80 ha of arable crops. One block of land, 89 ha, is situated 5 km from the home farm. The land lies at 90-140 m above sea level and varies from clay loam to sandy loam. The annual rainfall is 620 mm.

There has been a succession of changes in the management of the farm since the introduction of milk quotas, with the aim of increasing milk production from our own resources The milk produced from forage is currently 3500 1/cow compared to 2600 l in 1984. This has been achieved by a steady process of improvements in grassland management and introducing fodder beet, maize and white clover into the system. By contrast, the current national average production of milk from forage is 2200 l/cow.

White clover was first managed in a small area of grassland in 1990 since when its use has been steadily increased. Participation in an mmb/sac project entitled "extensification of milk production using white clover" has encouraged a greater reliance on the clover component in the swards. The grassland area is divided into approximately 28% permanent pasture and 72% which are 4 year leys in an arable rotation. At present there is little clover present in the permanent pasture, but it is now a key component in the short-term leys. The clover rich leys are used for both silage and for grazing the dairy herd.

Operating a mix of enterprises has enabled a more integrated whole farm system to be developed, in which clover plays a pivotal role (diagram 1). The benefits of incorporating white clover into the system extend beyond just the dairy herd. A flock of 340 ewes, predominantly north country mules, is kept. These lamb in february/march and the system has been developed to produce finished lamb of grass. Grazing clover rich swards at critical times in the production cycle has helped to improve productivity. After lambing the flock is moved onto grass clover swards where possible, the ewes are flushed before breeding on the grass/clover swards and the weaned lambs are finished on clover rich leys in the summer, early autumn. However, grazing the grass/clover swards with sheep during the winter period is vital for maintaining good clover contents in the following season. The arable crops in the rotation also benefit from the fertility built up by the clover. It is now possible to apply 125kg n/ha to the first wheat crop compared to 150kg as used previously, and maintain yield, protein content and

Diagram 1 Intergration of white clover into a mixed farm system



reduce costs. The reduction in inorganic n use has also reduced problems with lodging. The arable rotation also enables control of perennial weeds, which is difficult to achieve in the grassland without damaging the clover population.

We are aware of the losses of nitrogen that occur when clover-rich swards are ploughed up, and of the need to find more environmentally friendly and cost effective production methods. One potential solution is a technique known as bi-cropping, in which a cereal crop is grown directly in a sward of pure clover. An area of 2 ha of wheat is being evaluated this year using this technique. The winter wheat "cv pastiche" was drilled in october directly into a 5 year old clover rich sward in which the grass component had been removed by spraying with a low rate of glyphosate prior to drilling. No inorganic nitrogen has been applied and so far no chemical treatment has been necessaty to control pests. Bi-cropping has considerable potential as a low cost and a low chemical input system for producing high quality cereal crops. Once the cereal crop is removed a fut-ther crop could be drilled in or if disease builds up, grass could be estabished again in the clover.

Recently, cow comfort has been improved by building a new straw based housing system. Instead of housing the cows in cubicles, they are bedded on straw from the cereal enterprise. First lactation heifers in particular have benefited from the change, as there is less competition for access to feed spaces and cubicles. The change has had the additional benefit of reducing the amount of slurry produced. Increasingly strict regulations on the storage and spreading of slurry is making solid farm yard manure a more cost effective and flexible alternative for producers with access to cheap straw.

The conversion to a white clover based dairy system was initially made possible by a reduction

Table 1 Animal performance

	1992	1994
Milk yield (l/cow)	5365	5893
Milk fat (g/kg)	42.12	42.17
Milk protein (g/kg)	33.18	33.17
Concentrate use (kg/cow/day)	1025	1077
Milk from forage (l/cow)	3266	3733
Inorganic N use (kg/ha)	118	61

in stocking rate to 1.8 lu/ha by the purchase of additional land. Subsequently, once the grass/-clover swards become established and productivity increased, it has been possible to increase the stocking rate to 2.2 lu/ha. Since the introduction of clover, inorganic nitrogen use has been significantly reduced. The addition of clover and the other complimentary forages, fodder beet and maize, has helped to reduce concentrate inputs whilst simultaneously improving milk production (table 1).

The grass/clover leys are established in the autumn after winter barley. The seed is drilled onto the sut-face using an air drill. A mixture **of** 25 kg intermediate perennial ryegrasses (50:50 diploid: tetraploid), 2.5 kg Timothy *(phleum pratense)* and 2.5 kg white clover (Ensign blend) is drilled per hectare. Two cuts of silage are made. The two 500 t self feed clamps are filled with first cut herbage for the dairy herd. The fodder beet and maize are fed along a covered outside feed bunker and it has not been felt necessary to invest additional capital in a mixer wagon and the associated machinery and feeding passages. The grazing swards are set stocked at turnout and when silage aftermaths are introduced a rotational set-stocking system is practised. The rest period is seldom more than 4 - 5 days to minimise the variation in clover intake which has so far prevented problems with bloat.

The aim of the business is to produce 4000 l from forage in a low input sustainable system and maintain high milk quality. This will help to ensure that the margin over purchased feed and forage costs is maximised and that farm profitability can be maintained with lower milk prices.

Sustainable dairy farming: viewpoint of a Flemish dairy farmer

M. Halewyck (farmer from De Haan, Belgium)

1 Flemish situation

1.1 General regulations

Belgium is a federal State, consisting of two regions. Both regions have their own government. Environmental issues are under the authority of the regional governments. As we are living in the northern part of Belgium, Flanders, I will report on the Flemish situation.

We have had slurty regulations since 1991. The intention was to make the regulations more stringent after three years. However, as this is still being discussed we can only report on a slurry plan that is maturing amongst heated politica1 debate.

Let's have a look at the regulations now.

From January 1, 1996 till December 31, 1998 all the nitrogen can be applicated as slurt-y. However, in some cases, phosphorus will be a limiting factor. For grassland, too much slurry will cause taste problems. The amount of potassium will limit slurty application as well due to health-problems with cows.

The regulations from Januaty 1, 1999 till October 1, 2002 will be introduced after an evaluation of the previous years.

In 2002 final goals will be established which will be evaluated after three years.

The next table shows how a split between organic and chemical nitrogen will be introduced.

1.2 *Excep tions*

Ecologically valuable areas and bird protection areas have tougher regulations, which will come into force immediately after finalizing of the negotiations in Flemish parliament.

Furthermore there will be special green areas with zero fet-tilization from August 1, 1998. An exception to this rule can be made for those fields where the farmer makes a special green area management agreement with the Ministry of Environment. This means that farmers have no

Table 1 Before 1991: the choice of organic and chemical nutrients is free. From 96 on the new decisions are shown.

Crops	P_2O_5 phosphorus	N nitrogen	N from mineral origin
Maximal admitted quantities till the end of '95			
Grassland	200	400	
Maize	200	400	
Crops with low nitrogen demand	150	400	
Other crops	150	400	
Maximal admitted quantities in kg/ha/year. from 01/01/96 till 31/12/98			
Grassland (96-97-98)	170	450	250
Maize'96 160	325	200	
'97	155	325	200
'98	150	325	200
Crops with low nitrogen Demand ('96, '97, '98)	125	170	125
Other crops	150	325	225

Table 2 Split up between organic and chemical nitrogen

Crops	P_2O_5 phosphorus	N	Nitrogen from animal manure and other fertilizers	Nitrogen from chemical fet-tilizers
Definite admitted quantities in kg/ha. year [1]				
Grassland	125	450	250	250
Maize	100	275	225	130
Crops with low nitrogen demand	100	125	125	70
Other crops	100	275	200	150
Fertilization limits inecologic valuable areas in kg P and N (ha. year) [2]				
Grassland	120	420	250	200
Maize	100	275	170	150
Crops with low nitrogen demand	80	125	125	70
Other crops100	275	170	150	
Fet-tilization limits in water collectionareas and nitrate sensible soils				
Grassland	120	350	200	200
Maize	100	275	170	150
Crops with low nitrogen demand	80	125	125	70
Other crops	100	275	170	150

[1] There are a lot of exceptions to these regulations
[2] For Nitrogen sensitive areas and drinkingwater production areas and phosphorus saturated land the organic nitrogen must even be lower

choice at all: absolutely nothing, or strong regulations with a fee. All these special care areas contribute to one third of the agricultural area of Flanders.
This situation creates an enormous pressure on renting and owning land. A stand still on cattle, pig and poultry farming has also been decided. The numbers of the listings on May 15, 1992 will be fixed. New permits for farming are only obtained if the farmer owns or rents enough land for slurry spreading, in according with the new regulations. In addition, the total amount of nutrients produced in each village may not exceed the amount of May 15, 1992.

1.3 *Slurry spreading and s torage regula tions*
In some periods slurry spreading is not allowed at all:
all Sundays and holidays; all Saturdays except from February 1 till May 15; before 7 a.m. and after 22 p.m. (Figure 1).
Another obligation is the need for a 6 month storage of slurry.
Exceptions to this rules are made for farmers who are more than 59 years old, and declare that they will end their farming activities by January 1999 at the latest.

1.4 *Current situation on M. Halewyck's farm*
Let's have a look at our own farm situation:
total surface: 32 ha = 21 ha grassland + 11 ha maize
livestock : 52 dairy cows
23 offspring 0 - 1 years old
23 offspring 1 - 2 years old
Table 3 shows the calculated nitrogen and phosphorus production with this livestock.
Table 4 shows the permitted nutrient production according to the current regulations.

1.5 *Situation with final goals for 2002*
As can be seen in Table 6, P_2O_5 is not a problem.

The total nitrogen allowed:	12475 kg N
Total nitrogen through own production:	6585 kg N
Total chemical fertilizer to buy:	5890 kg N

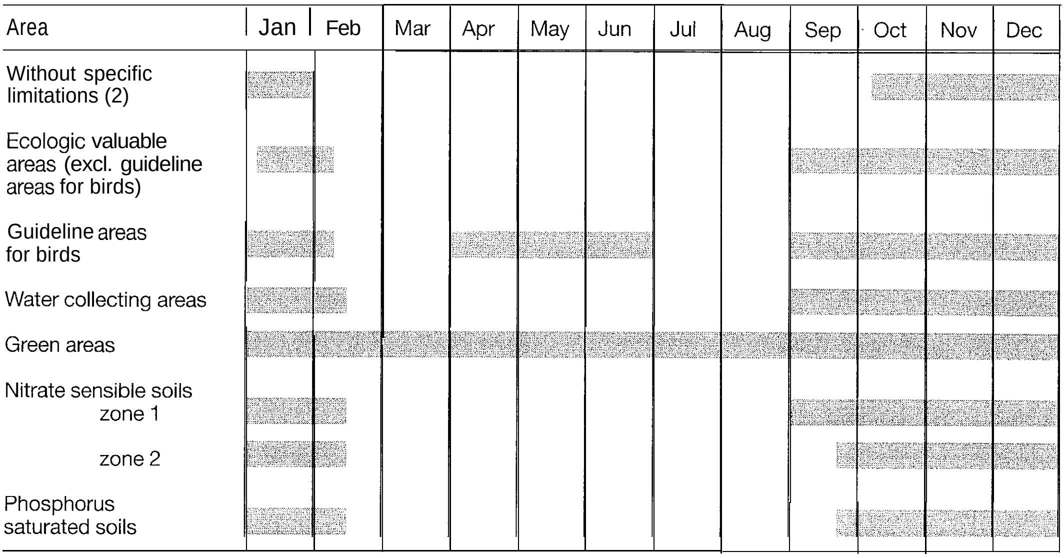
Even with a greater estimated nitrogen production per cow, we are able to produce good grass and maize. If we simulate the situation for colleagues in areas of some ecological value, we obtain the results in Table 7.

The total nitrogen allowed:	10375 kg N
Total nitrogen through own production:	-6585 kg N
Total chemical fet-tilizer to buy:	3790 kg N

There is too much slurry on the farm. The amount of nitrogen that can be bought (118 kg N/ha) is not enough for sufficient silage production on the farm. Table 8 is a compairison of the current situation and the final goals.

1.6 *Mixed farms*
In the real green areas agriculture is impossible. The amount of money the government has

Figure 1 Non allowed periods for slurry application in specific areas



allocated for all these hectares makes it a symbolic payment.

In Flanders we have lots of mixed farms. They have cow and pig farming and a few hectares of land. Even with the regulations we have today, these people have high taxes to pay. They need to transport their slurt-y to typical arable areas, which is also very expensive.

1.7 *Solution to spread slurty in spring*

In the debate about this slurty plan we brought up the idea of creating differences in spreading policy with respect to soil type. We have received no positive answer up to now.

Sandy soils and the heavy clay soils that we have, require totally different treatments: On sandy soils one can spread slurry in spring, plough it and plant the maize crop.

Table 5 Fet-tilization situation at M. Halewyck's farm in 1994.

	N (kg)	P_2O_5 (kg)
Animal production	6585	2427
Bought in chemical	6200	80
Total	12785	2507

Table 3 Nutrient production on M. Halewyck's farm

	N		P_2O_5	
	kg/unit	Total (kg/year)	kg/unit	Total (kg/year)
52 cows	87.15	4531.80	34.49	1793.48
23 0-1 y.	33.48	770.04	10.33	237.59
23 1-2 y.	55.80	1283.40	17.22	396.06
Total		6585.24		2427.13

Table 4 Allowed fertilization on M. Halewyck's farm with current norms.

Sut-face	Allowed N (kg/ha)	Total N (kg)	Allowed P_2O_5 (kg/ha)	Total P_2O_5
21 ha grassland	400	8400	200	4200
11 ha maize	400	4400	200	2200
Total		12800		6400

Table 6 Allowed fertilization on M. Halewyck's farm with final goals.

Surface	Max. N_{org} (kg/ha)	Total N_{org} (kg)	Max. N_{org} (kg/ha)	Total N_{org} (kg)	Max. N (kg/ha))	Total N (kg)	Max. P_2O_5 (kg) (g/ha)	Total P_2O_5
21 ha grass	250	5250	250	5250	450	9450	125	2625
11 ha maize	225	2475	130	1430	275	3025	100	1100
Total		7725		6680		12475		3725

Table 7 Allowed fertilization on M. Halewyck's farm with final goals, simulated for area of ecological value.

Sut-face	Max. N_{org} (kg/ha)	Total N_{org} (kg)	Max. N_{org} (kg/ha)	Total N_{org} (kg)	Max. N (kg/ha))	Total N (kg)	Max. P_2O_5 (kg) (g/ha)	Total P_2O_5
21 ha grass	200	4200	200	4200	350	7350	120	2520
11 ha maize	170	1870	150	1650	275	3025	100	1100
Total		6070		5850		10375		3620

Our heavy clay soils need to be ploughed before winter. It is impossible to drive on these fields with slurry tanks in spring.
Moreover, if one does so, soil structure will be damaged so badly that no crop will grow on it.

The intention of slurry application plans is to reduce slurty production, and to use it at the best moment for plant growth. We searched for a solution to be able to spread slurty at that moment in springtime. We found it in a hose

Table 8 Current situation and final goals

	Current situation		Final goals	
	N 400 grass 400 maize	P 200 grass 200 maize	N 450 grass 250 maize	P 125 grass 100 maize
Manure production	6,5	2,4	6,5	2,4
Allowed fertilization	12.8	6,4	12.5	3,7
Bought	6,2	0,08	5,9	0

Table 9 Analysis results of waste water.

	pH	COD (mg/l)	Total N (mg/l)	Total P (mg/l)
Draining point	7.47	140	36.4	6.42
End of reed ditch	7.68	20	1.4	1.87
Effluent norms VLAREM II	6.5 - 8.5	50	20	3

system: a hose pulled by a tractor with a slurry injector. Another injector provides us with the possibility of injecting into grassland. In this way we avoid heavy compression and structural soil damage.

2 The reaction of the farmers

Most of the farmers cannot imagine why they are being dealt with so severely.

Some of them react with well organized protest actions, others act in an uncontrolled way, and thus deteriorate image of farming.

A minority cross the borders to visit colleagues, and read internal and external magazines and newspapers. They are aware of the change in public opinion, and are ready to help in the search for solutions. They realize that farming only has a future if it takes care of the environment, good water and animal welfare.

But the public also needs to know that 'Farmers feed the world'.

Cooperation between these opposing groups wilt create more of a future than with opposition.

3 What about waste water on the farm?

Waste water ran off into a ditch, about 500 m long before entering a public watercourse. The last 400 m was completely overgrown with reeds. (Figure 2)

Table 9 shows you the analysis of our ditty water at the draining point at the end of our own reed ditch, with the current effluent norms. We were very satisfied with the results. But officials argued that the polluted distance is too long. We need to realize the water treatment in the first one hundred metres.

There we have no reeds at all because of the pollution. The problem was solved in the following way: at the draining point we constructed a 30-inhabitant equivalent septic tank, which is the first step in the treatment. The effluent flows into the ditch where we planted reeds and cats tails. Now we hope to achieve our initial results again.

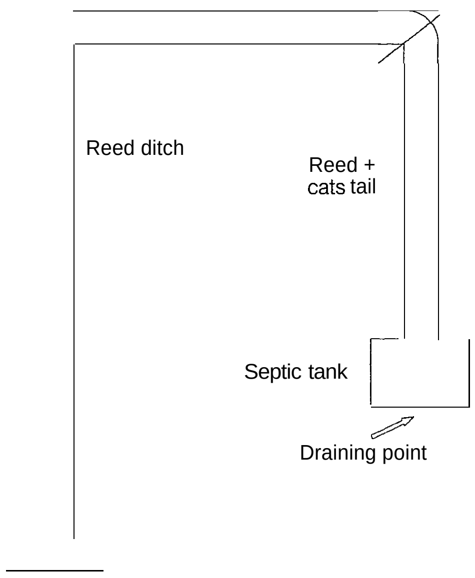
4 What is the future?

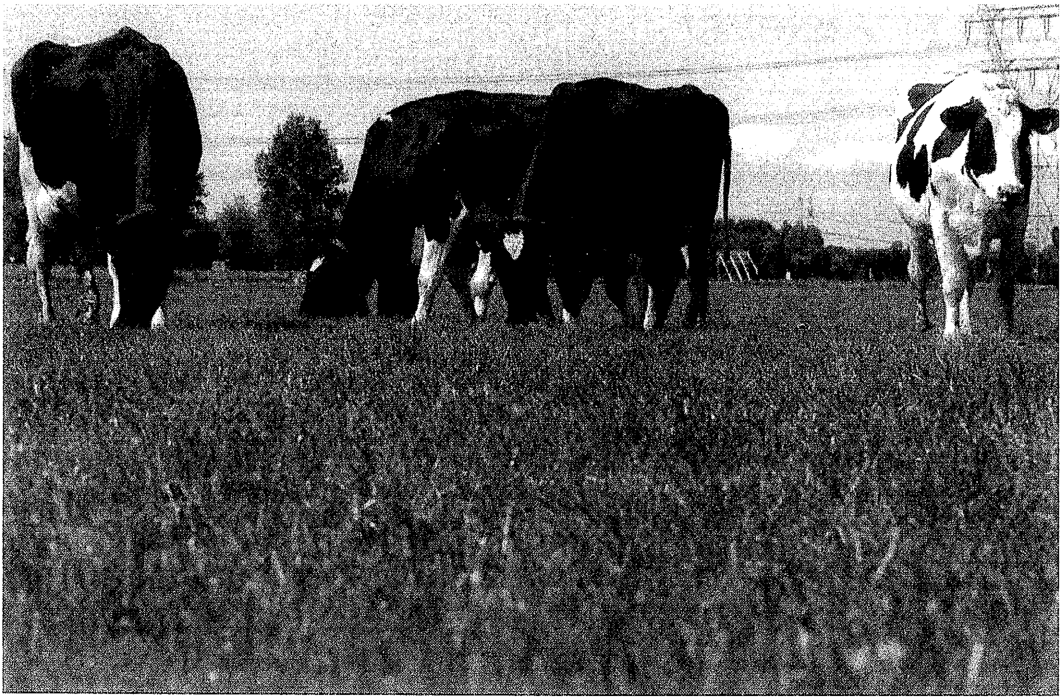
During the twenty-five years P.R. has existed, there have been tremendous developments in daity farming. This has resulted in higher labor productivity and better cattle housing, production and consetvation of silage, selection and breeding of plants and cows, as well as improved milking procedures, even robot milking. Complete farm management has reached high levels. The whole situation has led to a higher family income. As close neighbours of the Netherlands, we have had the opportunity of benefiting from the research that has been done here. We are very grateful for this possibility.

Now we are at a turning-point.

In the near future all efforts must be directed towards more "sustainable dairy farming." Future consumers will only buy our products if they are produced in line with their ideas on nature, environment and animal welfare. It will be a challenge for farmers to steer the consumers' ideas about the meaning of animal welfare. When does a cow feel happy? Provided with a wide range of tasty food, an attractive green pasture?

Figure 2 Waste water flow April1, 1994





A well-bedded stall or free shed housing? A clean milking parlor where she likes to release her milk after gently stimulation of her udder? Or does she really need a sofa, crisp, beer and a soap on television?
The challenge for the scientist will be to petform continuous research on feeding and housing the cows with the lowest possible nutrient emissions. The economic side of the story must not be forgotten. If fixed and variable costs become too high, farming will not be possible anymore.

5 Sustainable dairy farming

Basic ideas for sustainable dairy farming comes from European Community declarations. As a practica1 farmer, I visit colleagues in neighboring countries. In addition a lot of colleagues from other countries visit my farm. You wouldn't believe how different the same EC regulation can be when translated to the different countries, especially on issues such as nutrient production and application, ammonia emission and waste water problems. Farmers will tackle this challenge if they can rely on uncontroversial reports. Agricultural research stations and scientists from all EC countries need to cooperate and synchronize their effotts to find practica1 and affordable solutions to future dairy-farming problems. My wish to all of you: make the most of this opportunity.

Several years' efforts towards sustainable dairy farm management

J.L. Uitentuis
(farmer from Middenbeemster, The Netherlands)

Jan and Hetty Uitentuis have a a moderately sized family farm. They aim at a sustainable form of dairy farming. Management focuses on good economic results and optimum use of minerals. Crop nutrition emphasizes the maximum utilization of nutrients from the farm's own manure, whereas animal nutrition focuses on the optimum use of farm-grown forage. These efforts have resulted in a sharp decrease in the mineral surplus, while the economic result is maintained.

1. Our farm

Let me start by introducing myself. My name is Jan Uitentuis, together with my wife Hetty, I have a daity-farm. Our farm is located in the province of Not-th Holland on marine clay soil and has a size of 29 hectares. The layout of the farm is not ideal, with the area of plots nearby the farm buildings being only 8 hectares. Another area of 16 hectares is across a busy road, whereas the remaining 5 hectares is at a distance of 4 km. The herd consists of 42 dairy cows and 35 young stock. The quota is 305,000 kg milk with 4.39 % milkfat. The last few years, we have had about 23 hectares of grassland and 2 hectares of forage maize. In addition we let an area of 4 hectares for flower bulb or potato cropping. The resulting crop rotation of arable land and grassland is such that the grassland is renewed at regular intervals. The farm labour requirement is equal to one person. The work is actually performed by both man (80%) and woman (20%). This is because we both also have other activities outside our farm.

2. The MDM project

Since May 1992 our farm has been participating in the Minerals in Dairy-farm Management (MDM) project. Goal of the project is to realize and demonstrate sustainable dairy farming. To me, personally, “sustainable” is to be defined as: producing in an economically justified and socially accepted way. I think the object of the MDM project in our situation can be represented as follows: To what extent is it possible to carry out animal production on an average family farm in an economically justified way while paying attention to the environmental requirements. What will be important are the requirements which society will make in the near and somewhat remoter future.

3. Crop nutrition

Crop nutrition on the farm is based on a computerized fertilizer recommendation programme. Basic principle is the optimum use of the nutrients present in animal manure from the farm. For the last 7 years, we have used shallow-injection technique for slurry application. Of each paddock soil analyses (P and K) are made every three years. The application of organic manure en anorganic fertilizer is based on these analyses. The level of nitrogen supply to grassland has been chosen so that sufficient forage is produced for the own herd. As regards forage maize, band placement of anorganic fet-tilizer is only practised to a limited extent, in addition to slurry application. The nitrogen supply to the forage maize is based on soil nutrient availability.

4. Animal nutrition

In animal nutrition we have a simple feeding strategy. Basic strategy for animal nutrition is that the cows are given farm-grown forage as much as possible. Whenever possible, day and night grazing is applied in summer. On average, the winter rations consist of two-thirds of grass silage and one-third of maize silage. Both in summer and in winter the forage is supplemented with concentrates and with individual minerals, if necessaty, to meet the feeding standard. Concentrates are given through a feeding-computer. We participate in a group of farmers who exchange information and knowledge on nutrition-manegement. A specialised extension worker supports this group. He makes rations-calculations and advises about concentrates and minerals we have to feed.

5. Animal health

Our farm obtains regular veterinary support, espacially focused on the fertility of the herd. Good fertility parameters are a result of this regular support. The between calving period is normaly around 380 days. Much attention is paid to preventive health care. This has resulted in a healthy herd, without serious disease-problems. Leg-problems and mastitis are still the most frequent. Other diseases are rare. Within the framework of the MDM project, the Animal Health Service takes blood and urine samples twice a year. This provides us with extra information on the health status of dairy cows and young stock. This has learned us for instance that the mineral supply (e.g. Mg and Cu) of the animals is sufficient.

6. Economics

Since 1987 we have been involved in farm economic accounting. This system not only brings the variable costs (such as feedstuffs) into vision, but also the fixed costs (machinery and buildings). Strategic decisions, such as regarding the purchase of land or milk quota, or deciding between contract work and own machinery, are taken on the basis of the accounting reports. Based on these accounting reports we decided to gradualy change from using own machinery to hiring contractors for the fieldwork, mainly slurry application and silage making. The accounting reports are also used for tactical decisions. The report shows you your strong en weak points, so you know where you have to pay extra attention. Comparing your own figures with the results of fellow-farmers is also very stimulating.

7. Mineral balance

During the last years, a mineral balance has been added to the anual economic report. The mineral balance is a measure of the nutrient losses. It indicates the difference between the input of nutrients by means of e.g. feedstuffs and fertilizers and their output through milk and animals. This difference, the mineral surplus, is expressed in kilograms per hectare and is calculated for nitrogen, phosphorus and potassium. The lower the surplus per hectare, the lower the emissions into the environment. Through the mineral balance we get a good view over the mineral flows in our farm. First we were surprised about the heigth of the mineralsurplus. Since then we have tried to reduce the mineral surplus, because we think that in order to become sustainable we

Table 1 The main parameters of the Uitentuis farm in 1897/88 en 1993/94

	1987/88	1993/94
Grassland (ha)	22.2	22.9
Maize land (ha)	2.0	2.3
Dairy cows (number)	48.6	42.8
Young stock (number)	26.1	37.7
Milk production (kg)	321 ,143	309,046
Milk yield per cow (kg)	6606	7221
Fat content (%)	4.35	4.44
Protein content (%)	3.36	3.44
Fertilizer N (kg per ha)	429	246
Concentrates per cow (kg)	1666	1768
N surplus (kg per ha)	470	284

must reduce the emissions to the environment.

8. Results

The main parameters for 1987/88 and for 1993/94 are given in Table 1.

Over the last years there has been a marked decrease in the input of fertilizer N. The application of fertilizer N averaged over 400 kg per hectare in the first years, this was down to about 245 kg per hectare in 1993. This decrease was caused partly by a decrease in fertilizing level and pattly by a much improved utilization of organic manure. Forage maize cropping has also attributed to a lower N use. Within the farm economic accounting framework the net energy production per hectare of grassland is calculated. Figure 1 shows that the net energy production has been maintained, despite the much lower input of anorganic-N. The modifications in the crop nutrition practice have not

Figure 1 Net energy yield of grass (kVEM/ha) and anorganic N-fertilizer (kg/ha) of farm Uitentuis

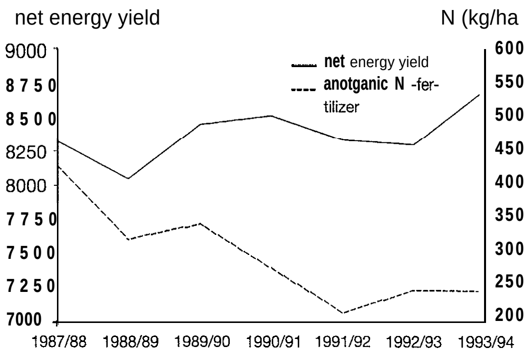
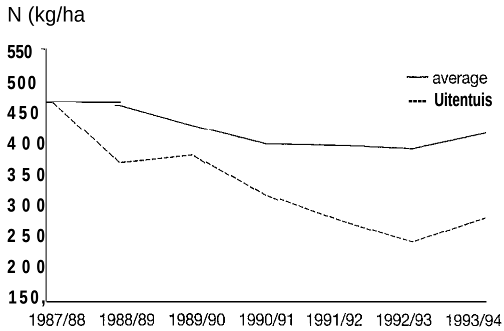


Figure 2 N-surplus (kg/ha) of farm Uitentuis compared with the average of Dutch farms



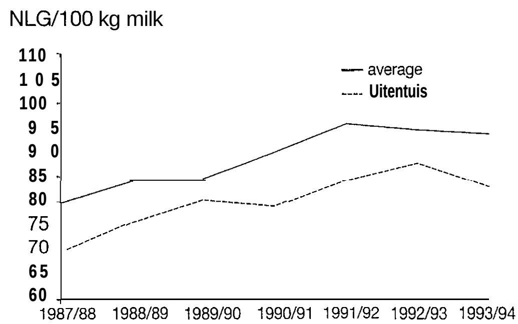
adversely affected the quality of forage. Soil fertility has also been maintained.

In 1987, concentrate consumption per head (including young stock) was nearly 1700 kg per cow. In 1993, with a larger number of young stock, concentrate consumption amounted to 1770 kg per cow. In the intermediate period, milk yield increased from 6600 kg to 7200 kg/cow. The increase in milkproduction is mainly due to the genetic improvement of the cows.

Figure 2 compares the nitrogen surplus of our farm with the average Dutch dairy farm and clearly shows that our figures have dropped considerably. As stated before, this is mainly due to a lower anorganic fertilizer input whereas also the input of concentrates has been reduced somewhat. Per cow we have been feeding a little bit more concentrates, but because we have fewer cows the total input of concentrates is lower.

The economic results of the last few years show that the fixed costs relatively account for an increasing share in the cost price. The fixed costs

Figure 3 Cost price of milk (NLG/100 kg) of farm Uitentuis compared with the average of Dutch farms



include those of labour, buildings/land, and contract work. The variable costs (feedstuffs, fertilizers) remain fairly stable. Figure 3 shows how the costs per 100 kg milk have developed on our farm. Our costs are compared with the costs of the average Dutch dairy farm. The diagram shows that the position of the farm has not changed, compared with the average performance. We still achieve a low cost price.

9. Conclusion

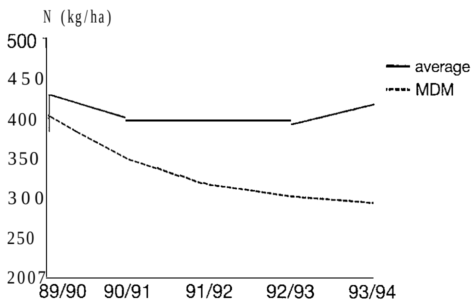
Looking back upon a number of years with a modified farm management, I think it is justified to conclude that under present-day economic conditions we may call this a sustainable type of dairy farming. From the figures it is clear that we are ahead of the average Dutch dairy-farmer. On the other hand it has to be admitted that we do not yet kwow the requirements which society will set on us in the near future.

Minerals in Dairy farm Management

In Dutch the title of the project is Management on Sustainable Dairy farms. The objective of the MDM project is to realize and demonstrate sustainable dairy farming. Sixteen farms patticipate in the project. They are scattered all over the country. Several institutes monitor and research the group of farms for technical and economical aspects. The leading theme of the project is mineral management. The participating farmers try to improve the mineral-utilization and in the meantime maintain good economic results.

The last few years, the mineral-surplus of MDM farms has gone down substantially (figure 1). Furthermore, there appears to be room for the surpluses to be reduced even further. The reduction is achieved mostly through an optimum use of minerals present in animal manure. The input through concentrates is also reduced. The economic results of the MDM farms are well in line with those of the other specialized dairy farms. In the first two years the average margin over costs per 100 kg of milk on the average MDM-farm was NLG 19.85. For the average dairy-farm this margin was NLG 18.87 per 100 kg of milk.

Figure 1 N-surplus MDM-farms and average Dutch



All technical and economic data are immediateiy available to farmers, because the pat-ticipating farms receive fellow-farmers on their farm. In the initial two years, nearly 5,000 people have visited a MDM-farm or have attended a lecture from a MDM-farmer. 80% of the people are dairy-farmers or directly related to dairy-farming (e.g. extension workers).

Conclusive remarks on sustainability in dairy farming

M.C. *Verboon, W. Luten and S. Schukking (PR-Lelystad)*

Looking at the question what sustainability means we have to realize that there is room for different interpretations. The contributions to this symposium agree that finally we had to indicate what our needs are at this moment and in future. By answering these questions not only measured values are necessary, but also norms determined by society how to produce and realize our needs. Thus, sustainability depends also on politica1 decisions; technically it is a complex relationship between economy, environment, nature and landscape.

According to the United Nations Conference on Environment and Development (1992) most agricultural systems are not sustainable. Therefore, agricultural research has to develop technologies that are sustainable. The Netherlands has generally accepted an emission-poor future as a sustainable system. The instruments are legislation and technical solutions, but also information and extension.

This symposium contributes to a better understanding of the environmental problems and to identify realistic options for remedial activtities and long-term developments. Results are reported and suggestions are proposed. Basically in two directions: first how to adapt current production systems, and secondly to develop new production systems in order to improve or reach sustainability in dairy farming.

Goals and objectives

Sustainability is an issue with many facets. Indicators are necessaty to asses sustainability in dairy farming. The formulation or definition of these indicators starts with setting goals for ecological, economic and social sustainability. These goals can be divided into a number of objectives.

By mutual arrangement between government bodies and farmers' organizations several objectives are set for nitrogen, phosphorus, nature and landscape. Farmers have already stat-ted to improve nutrient management by keeping account of input and output of nutrients on their farms and by reducing unnecessaty losses. A check-list can help farmers to manage the more efficient use of several other environment-related inputs and natural resources such as water, energy, pesticides and disinfectants.

The income related aspect of sustainability is as much an item of research as the environment-related aspect.

In the different countries which met at this symposium the attention is mainly directed to nitrogen, phophorus, nature and landscape.

In the northern part of Belgium slurry regulations exist since 1991. It was the intention to make the regulations more strict after three years. A small number of the farmers realize now that farming only has a future if it takes care of the environment, water quality and animal welfare.

Denmark has according to UN Conference on Environment and Development (1992) accepted tasks to describe and evaluate indicators with which it gives a scientific basis for sustainability of the livestock farm as a component of an ecosystem.

In France about half of the dairy farms are located in permanent grassland areas including mountains where a large part of the milk is convet-ted into high quality cheese. "The West" of France has less specific dairy products and is more open to the European market. Nevertheless, even there exist already some economically efficient and environmentally friendly daity farms within a wide range of milk yields and stocking rates.

In Germany, various governmental programs exist which link economy and ecology. Nevertheless, all existing programs cannot avoid that the farmer's income will decrease, if the production volume cannot be enlarged.

In the UK, a fundamental shift in government thinking towards agriculture has taken place during the last ten years. Government policy is moving towards a 'greening' of agriculture and promotion of sustainable farming systems. Currently, the dominant influence on dairying is from legislative measures to reduce the environmental impact from silage effluents, animal wastes and nutrient inputs.

Adaptation of production systems

A number of management practices influence the N-losses on a dairy farm. Discussion was directed to a better and lower use of fertilizer N, ration balancing, lowering stocking rates and restricted grazing, injection of slurry, low emission housing and covering slurry storage facilities.

Fertiliza tion and weed con trol

The utilization of nitrogen from slurry has improved considerably due to a change in application time and the use of new application techniques. On an average, the utilization of slurty nitrogen almost doubles when applying low emission techniques in stead of sutface spreading. This contributes considerably to the reduction of nitrogen losses on dairy farms. On arable land, low emission methods of slurry application will also reduce nitrogen losses significantly.

Although reduction of N inputs cannot be avoided when meeting environmental goals, the improved utilization of fertilizers can significantly compensate for the decrease in yield. The most important aspects of fertilizer recommendations are: a good estimate of mineralization and residual effects of preceding N applications. Research is going on towards omitting fertilization of urine spots.

On arable land nutrient utilization can be improved by adjusting fertilizer input rates and the time and place of their application to soil and crop characteristics. Residual N left in the soil in the autumn can be taken up by catch crops. Chemical weed control can be replaced by mechanica1 weed control. Additionally, dose and timing of chemical treatments can be adjusted to weed development, resulting in reduced input.

Feeding and health

The long term research input into understanding rumen N metabolism in ruminants is now supplemented by research on soil N processes, nutrient efficient forage production, and animal health and welfare.

A diet that contained a small surplus of Rumen Degradable Protein (RDP) resulted in a considerably lower emission rate of ammonia, compared to a diet which contained a high surplus of RDP

A newly developed protein evaluation system in which the supply of absorbed amino acids is related to the supply of net energy, offers the oppottunity to reduce losses of N by feeding according to more exactly defined protein requirements of dairy cows. Improvement of the N utilization can be achieved by a decrease in dietary N level while productivity is maintained constant. In dairy production systems mainly based on grass and grass silage, reducing the dietary N level can be achieved by a lower N content of grass or grass silage owing to a reduced N fet-tilization level or by supplementing with feedstuffs with a relatively high energy and low protein content.

For sustainable dairy farming with high yielding cows control of health and reproduction is necessary. It has been shown that high yielding cows should be inseminated later. Patterns in somatic cell counts should be determined by monthly milk recording. Automatic recording of milk production, conductivity and temperature in milk and cows' activity may be helpful tools for health and reproduction management.

Housing and milking

The ammonia emission both from a loose house with feed-in cubicles and from a tied housing system is lower compared to the emission of a reference cubicle house. Research on ammonia emission reduction from cubicle houses is geared towards the rapid removal and storage of urine. This can be achieved using a sloped floor that facilitates run-off. Acidification, by applying nitric acid to the manure in cellars below cubicle houses has proven to be very efficient in reducing ammonia emission. Roof constructions and floating covers reduce the emission of ammonia from slurry stored outside the cattle houses considerably.

Various methods to reduce amounts of water, chemicals and energy for cleaning miking equipment have been investigated. The results indicated that considerable savings are possible in this respect without affecting milk quality.

Economy

In practice there are several efforts towards sustainable dairy farm management. In a creative way they showed that there are possibilties while economic results are maintained.

In practice dairy farm management in the Netherlands focuses on good economic results and optimum use of minerals. Crop nutrition emphasizes the maximum utilization of nutrients from the farm's own manure, whereas animal nutrition focuses on the optimum use of farm-grown forage. These efforts have resulted in a sharp decrease in mineral surpluses, without affecting the economic results of the farms.

The most cost effective strategies for reduction of the nitrogen surplus are management changes such as increased milk yield, reduced N fertilization level on grassland and reduced emission during slurry application. The compulsory covering of slurry storages is less cost effective. Housing systems to reduce ammonia emission like a sloped floor and especially a slatted floor with flushing are still very expensive.

Change to new production systems

The decline in biodiversity of the natural environment has resulted in plans for the development of nature and landscape. Also a better use and saving of water and fossile energy can prevent depletion of natural resources.

In different countries contributing to this symposium some areas are marked as ecologically sensitive area, consisting predominantly of grassland. These natural grasslands are considered suitable for feeding suckling cows. A good co-operation between farmers in those areas is an important condition to reach sustainable targets. As the area of natural grassland will increase, the necessity to develop low-tost farming systems will gradually become more evident.

New farming methods may render grazing animal husbandry soil-bound again. This implies extensification by reducing the stocking rate to Sustainable Stocking Rate and the milk quota to Sustainable Quota for Milk production.

The development of new production systems leads also to renewed interest in white clover. The nitrogen balance showed a shift from fertilizer to biological fixation, but the nitrogen utilization did not improve. Gross margins per cow can be slightly higher for grass/clover mixtures.

Organic farmers do not use fertilizers and chemicals at all, they limit concentrate use and try to contribute to nature and landscape conservation and animal welfare. Feed supply and quality, animal nutrition and profitability are the major limitations for a widespread use of this system.

Conclusions

Research has shown that several technical solutions exist to reduce the losses from dairy farms to the environment. Furthermore, on commercial dairy farms it is demonstrated that some of these solutions may lead to more sustainable farming systems with acceptable economic results.

Sometimes change to new production systems in cattle farming is necessary in order to reach the goals set for environment, nature and landscape. In general these systems are more extensive and need support to garantee a reasonable income to the farmers.

Posters

TEIE MIDAS PROJECT: DEVELOPING ENVIRONMENTALLY ACCEPTABLE DAIRY SYSTEMS FOR THE UK

S. Peel, A.G. Chalmers and P.J.A. Withers
ADAS Bridgets, Martyr Worthy, Winchester S021 1AP

In the United Kingdom there is considerable concern that nutrient losses from typical dairy farms may be unacceptably high. In particular, the concentration of nitrate leached may exceed the EU Drinking Water Standard of 50 mg/litre. There is also a need for further information on phosphorus cycling on dairy farms under UK conditions.

Methods

A large-scale study has been initiated at ADAS Bridgets in Hampshire to examine nutrient cycling and profitability within three self-contained dairy systems:

System 1	Good commercial practice (control).
System 2	Reduced loss, high output.
System 3	Minimal loss, reduced intensity.

Each system has 40 cows with a target milk yield of 6000 litres/cow. A range of techniques has been incorporated in Systems 2 and 3 so as to reduce losses of N and P, e.g. storage of slurry, reduced fertilizer use particularly for grazing, manipulation of feeding, use of cover crops in maize, reduced stocking rate (in System 3).

Monitoring

Detailed environmental monitoring of each system is undertaken, including:

Leaching	:	450 porous pots for nitrate, 90 teflon pots for phosphorus
Ammonia	:	Micrometeorological technique using 'shuttle' samplers targeted at slurry spreading.
		Wind-tunnel technique for relative measurements at grazing.
Nitrous Oxide	:	P.A. I.R. technique being developed.
Erosion	:	10 erosion traps, in maize and grass.

Conceptual models of nutrient flow have been used to devise each system and target the monitoring strategy to areas of expected high loss.

Results

Planning and land allocation commenced in October 1993, and systems were fully established by August 1994. Prehminary results from the setting-up year are now becoming available. Examples are given below:

	Nitrogen input (kg/ha)		Nitrogen leached (kg/ha)*
	Fertilizer	Available N in Slurry+	
Permanent grass			
System 1 Grazed all or most of season	**290**	**0**	**60**
Two silage cuts then grazed	311	21	53
System 3 Grazed all or most of season	130	0	27
Two silage cuts, then grazed	184	36	7
Maize			
Mean of Systems 2 and 3 maize	68	52	62

* Preliminary leaching data from early November 1994 to late January 1995
\+ Ammonia N; availability estimated according to Reference Book 209 (MAFF, 1994)

Discussion

- In a typical winter at ADAS Bridgets the estimated drainage is 260 mm; to keep nitrate < 50 mg/l the loss of N must be < 30 kg/ha.
- The winter 199415 was very wet; estimated drainage had already reached 230 mm by 20 January.
- Under permanent grass mean leaching loss was substantially less on the improved system than the control system.
- Loss under maize was relatively high despite the use of an undersown cover crop of Italian ryegrass.
- The study will continue for at least three years, and includes full financial monitoring.

THE ROLE OF COVER CROPS IN REDUCTION OF NITRATE LEACHING ON DAIRY/ARABLE FARMS

S. Peel* and R Harrison * *

* ADAS Bridgets, Martyr Worthy, Winchester S02 1 1 AP, U.K.
** ADAS Arable Research Centre, Anstey Hall, Cambridge CB2 2LF, UK.

Many dairy and livestock farms in the UK, particularly those with arable enterprises, grow catch crops such as forage rye, forage rape or stubble tumips. As we11 as a useful source of fodder in winter or early spring, these species serve the valuable function of cover crops, taking up surplus soil nitrogen over autumn and winter on ground that might otherwise be bare. A large multisite experiment has been carried out over four years to examine the potential of a range of catch crop and cover crop species for reducing N leaching.

Methods

There were six sites on a variety of mineral soils, on which the catch crops were sown on 3 1 August or 15 September after ploughing winter wheat stubble. Results from a dry autumn (1991) and a wet autumn (1992) are presented.

Nitroaen uptake

	Nitrogen Uptake (kg/ha)	
	1 December	1 February
Dry autumn (1991)		
Winter rye	21	26
Forage rape	11	13
Stubble turnips	16	18
Wet autumn (1992)		
Winter rye	29	35
Forage rape	26	29
Stubble tumips	29	45

Winter rye was the species most consistently successful at taking up nitrogen in both the dry and wet autumns; the brassica species did well in the wet autumn. The environmental benefit was largely achieved before the onset of winter; N uptake by 1 December was generally at least 75% of that on 1 February.

Results from sowing catch crops on 15 October were very disappointing; in most years on most sites N uptake was less than 5 kg/ha by 1 December and less than 10 kg/ha by 1 February.

Potential Leachinq

	Soil mineral nitrogen, 0-90 cm (kg/ha) 1 December	1 February
Dry autumn (1991)		
Winter rye	77	101
Forage rape	95	123
Bare ground	110	141
Wet autumn (1992)		
Winter rye	41	56
Forage rape	47	60
Bare ground	75	80

NO direct measurements of nitrate leaching were made, but Soil Mineral Nitrogen (SMN), measured to 90 cm depth, was consistently higher on bare ground than under the catch crops. When the crop N uptake is added to the SMN values the totals are broadly similar to those under bare ground. This suggests that the soil disturbance associated with sowing the catch crops added relatively little SMN to the profile, and that the crop N uptake was likely to have reduced the potentially leachable N.

Conclusions

- Catch crops sown after cereal harvest can Capture significant amounts of soil nitrogen that might otherwise be lost.
- Winter rye is the most reliable species but the seed cost may be high.
- Forage rape and stubble tumips are cheaper to sow and can perform well, particularly from early sowings.
- In most years, the majority of the N uptake is completed by December, particularly with brassicas.
- Catch crops sown in October, for example after maize, will take up very little N.

Comparison of nutritive parameters of a perennial ryegrass hay and hay from species rich, extensively managed grassland

1. Verbruggen (1), F. Nevens (2), B. Kayaerts (3) and A Vermoesen (4)

National Centre for Grassland- and Green Fodder Research (IWONL)

(1) R.v.P.-Merelbeke
Burg. Van Gansberghelaan 109
B 9820 Merelbeke

(2) FLTBW-Universiteit Gent
Vakgroep Plantaardige Produktie
Coupure Links 653
B 9000 Gent

(3) Instituut voor Natuurbehoud
Kiewitdreef 5
B 3500 Hasselt

(4) FLTBW-Universiteit Gent
Vakgroep Bodembeheer en -hygiëne en Vakgroep
Toegepaste Analytische en Fysische Chemie
Coupure Links 653
B 9000 Gent

Introduction

In recent years there has been an increasing interest in the (re)establishment of species rich hay meadows that combine ecological and agricultural objectives In the context of extensification programmes of the EC and the national governments, it's important to know what the possibilities are to use hay of extensively managed grassland on a dairy farm with high production potentials of its dairy herd. The objectives of this work were to compare the nutritive parameters of a perennial ryegrass hay and hay from species rich, extensively managed grassland.

Materials and methods

Two different types of hay were harvested in 1994. The first type was harvested from a species rich meadow near the valley of a river and was extensively managed: no fertilisation and a late mowing date (first of July). The second was from an intensively managed grassland with a fertilizer level of 325 kg N/ha/year. In winter the two types of hay were used in a feed experiment with bulls of the Belgian White Blue race. A supplement of barley (2.6 kg/bull/day) was given each morning. The bulls had an adaptation period of 3 weeks to change from a maize ration to a hay ration. The two experiment periods took 3 weeks interrupted by an adaption period (2 weeks)

The hay was analysed for nutrient content and digestibility in vitro. Additionally, the in sacco degradability in sheep was determined.

Conclusions

Crude protein and digestibility of the organic matter are significantly higher in the ryegrass hay. Also the P- and K-content are remarkebly higher. The intake was greater for species rich hay, however not significant. The degradation rate as well as the degradability after 96 hours of the hay of the extensively managed grassland were lower.

Results and discussion

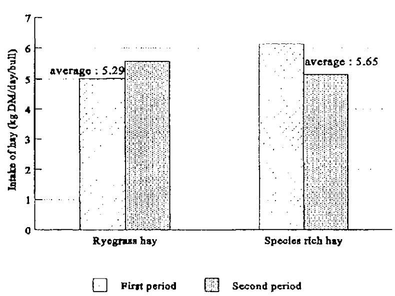
Table 1 : Typification of the grasslands where the hay was harvested

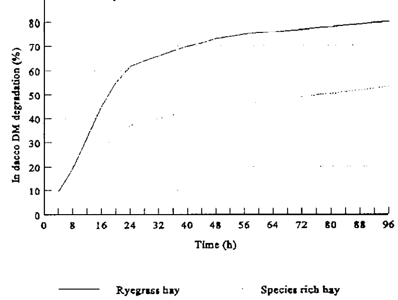
species rich grassland	Lolium perenne
soil: loam no fertilisation cut: first of July	soil: loamy sand fertilisation:325 kgN/ha/year cut: 25 May
species rich (#39) e.g.: * *Holcus lanatus* 21% *Trifolium sp.* 19% *Anthoxanthum odoratum 9%* *Ranunculus repens 7%* *Agrostis stolonifera* 6% *Bromus hordeaceus 5%* *Cynosurus cristatus 5%* *Other species <5%*	young *Lolium perenne* meadow

* cover %

Table 2 : Quality parameters of the hay (% DM)

	species rich grassland	perennial ryegrass
crude protein	7.52	14.48
crude ash	7.85	10.01
crude fibre	33.2	29.5
% Ca	0.50	0.50
% P	0.17	0.34
% K	1.20	2.72
% Na	0.19	0.15
% Mg	0.16	0 15
D-value	53.5	63.1
digestibility %OM	58.1	70.3





QUALITY OF MILK FROM CONVENTIONAL AND “DEMETER” FARMS

Hartmut Grimm and Willi Setzer-Mühlbacher

The buik milk data of 345 conventional farms and 93 farms producing according to the regulations of “biologisch-dynamischer Land bau" (DEMETER) were recorded. All farms delivered their milk to the same dairy. The mean quota of the conventional farms was about 51 000 kg milk, that one of the DEMETER farms was 80 000 kg. From all conventional farms 93 conventional farms with similar quota like that of the DEMETER farms were selected for statistical purposes.

The contents of fat, protein and DFFM were lower in the milk from DEMETER farms. The monthly fluctuations of these values were similar for both types of farms. No correlation could be found between number of cows or quota and the milk contents. Calculations of mean rations showed a lack of energy from 14 kg milk onwards, the same was found with fibre contents.

Mean somatic cell counts in the bulk milk of the conventional farms was 203 000, that one of the DEMETER farms was 211 000. Both types of farms had higher cell counts in late summer/autumn and lowest cell counts in May/June. A trend towards higher cell counts with higher quota could be observed, although those DEMETER farms with 160 000 kg and more had lowest cell counts.

Mean bacteria count in conventional farms was 48 000 and that of DEMETER farms was 65 000 bact./ml. Variation in DEMETER farms was much higher than in conventional farms. The mean value of each month was lower in conventional farms. Interviews on DEMETER farms reveiled that these farmers had many reservations against any chemicals and so used less or worse detergents and desinfectants for their milking installations.

Expert guidance for feeding and cleaning of equipment is strongly recommended.

UNIVERSITÄT HOHENHEIM

INSTITUT FÜR AGRARTECHNIK

Verfahrenstechnik in der Tierproduktion
und landwirtschaftliches Bauwesen

Environmental Consequences of an Early-Lactational Protein Deficit in Cows

F. Sutter and M. Kreuzer
Institute of Animal Sciences, Animal Nutrition, ETH Zurich, CH-8092 Zurich, Switzerland

PROBLEM

Reducing more than the excessive dietary protein amounts might seem desirable enough to tolerate certain adverse effects in milk yield for environmental reasons. Unsolved is, however, if deficient protein supply is efficient in reducing emissions at all, particularly if expressed per unit of milk produced.

METHODS

2 x 9 Holstein cows were fed post partum either adequate with protein or 25 % below requirements. Weekly, production traits as well as intake and excretion of various criteria by balance and respiratory techniques were followed for two months. Significant differences are given by 1, 2 and 3 asterisks for $P < 0.05$, $P < 0.01$ and $P < 0.001$.

RESULTS

Table 1: **Production traits**

Protein	Adequate		Deficient
Milk, kg/d[1]	34.1	***	25.6
Intake per day			
- Dry matter, kg	18.6	***	15.2
- Nitrogen, g	436	***	323
Live-weight, kg	612	*	558

[1] adapted for similar energy content

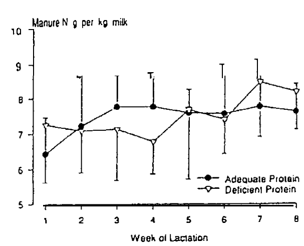
Table 2: **Emissions per day**

Protein	Adequate		Deficient
Manure, kg	54	**	46
Nitrogen, g	252	***	189
Methane, l	492	**	385
Carbon dioxide, l	6149	*	5401
Urine, % of			
- manure	23.7		24.1
- manure N	32.7		30.6

Table 3: **Emissions per kg milk**

Protein	Adequate		Deficient
Manure, kg	1.6	*	1.8
Nitrogen, g	7.4		7.5
Methane, l	14.5		15.2
Carbon dioxide, l	182	*	21.5

Fig. 1: **Development of N loss per kg of milk**



CONCLUSIONS

In contrast to the reduction of excessive protein, the use of deficient protein amounts even cannot be recommended in an environmental sense since the quantities released per unit of product are not reduced. Instead, a given quantity of milk should be produced with the lowest possible number of adequately fed cows.

GRASS AND GRASS-LEGUME SWARD IN FEEDING OF HIGH-PRODUCTION COWS

Rogalski M., Kruczyńska H., Kryszak J., Nowak W.

Agricultural University of Poznań, Poland

In the years 1993-94 experiments were carried out in conditions of pasture grazing on the yield of black and white cows crossed with HF. The experiments were conducted in the Experimental Station of Agricultural University.

The herd of 162-170 cows were kept on rotational pasture for 8 hours per day. The stocking rate was 3.4 head/ha and the pasturing season lasted for 170 days in the first year of experiment and 181 days in the second. The animals stayed for three days on each of 14 paddocks during every turn. Pastures were fertilized with the following low doses of mineral fertilizers: 100 kg N, 100 kg K_2O and 70 kg P_2O_5.

The studies were concerned with quantitative and qualitative changes of the obtained forage (Table 1).

Table 1. Pasture yield and sward fodder value

Sward type	Year	Annual yield t DM/ha	Crude protein % of DM	NDF % of DM	ADF % of DM
G	1993	7. 6 - 9. 8	14. 1 - 19. 2	27. 3 - 30. 1	47. 8 - 53. 2
	1994	5. 6-8. 3	17. 6 - 21. 6	26. 5 - 29. 5	45. 6 - 52. 5
GC	1993	7. 8 - 8. 4	18. Q - 23. 5	24. 2 - 29. 5	41.6-52. 1
	1994	5. 6 - 8. 1	18. 7-22. 6	23. Q - 27.3	38. Q - 49. 3

Ingestive behaviour and herbage intake of grazing cows on the pasture with the domination of *Poa pratensis (G)* sward and on the grass-legume pasture (GC) with a 20% share of *Trifolium repens* were also compared (Table 2).

Table 2. Grazing tirne, bite rate and herbage intake

Sward type	Year	Grazing time in h	Bite rate per min	Herbage intake kg DM / head
G	1993	5. 7 - 7. 3	47. 7 - 19. 2	8. 6 - 9. 9
	1994	6. 3 - 6. 6	48. 0 - 52. 7	6. 3 - 7. 0
GC	1993	5. 8 - 6. 8	47. 7 - 53. 5	8. 6 - 9. 1
	1994	6. 5 - 6. 9	46. 6 - 50. 5	6. 4 - 6. 6

The share of pasture herbage in basic feeding diets ranged from 72% at the beginning of the grazing season to 42 % at the end. 182 to 230 g of concentrates were used for production of 1 kg milk.

EFFECT OF THE HEIGHT OF WHITE CLOVER DURING HARVEST ON ITS GROWTH AND DEVELOPMENT

Kryszak J., Rogalski M., Walczak S.

Agricultural University of Poznań, Poland

In spring of 1993 an experiment with white clover in pure sowing was established. Plants were sown on 1 x 1 m micro-plots in four repetitions in a split - splot system on three soil textural classes: light, medium and heavy. The aim of this study was the determination of growth and development of white clover plants depending on the sward height at harvest time. For this reason, the following three sward heights were adopted as the defoliation criteria: 7 - 9 cm, 10 - 12 cm and 13 - 15 cm. In relation to the adopted sward height target, cutting frequency ranged from 6 to 8. Sward was cut with a mower which left stubble of 2 cm height.

This paper presents results obtained during the first two years of experiment (Table 1).

Table 1. Sward height and yield, stolon length and LAI

Examined trait	Year	Sward height (cm) 7 - 9	10 -12	13 -14
Annual yield (kg OM/ m^2)	1993	1. 22	1. 24	2. 01
	1994	1. 63	1. 74	2. 05
Stolon length (m / m^2)	1993	91. 5	113. 5	69.5
	1994	124. 4	134.3	95. 2
LAI	1993	2. 65	2. 89	2. 59
	1994	3. 53	4. 11	2. 95

Type of soil also influenced growth and development of white clover, for example on the number of petioles (Table 2).

Table 2. Effect of soil type on number of white clover petioles

Examined trait	Year	Soil type light	medium	heavy
Petiole no.	1993	13. 57	11. 44	13. 71
(thous./ m^2)	1994	15.45	13. 90	18.21

Conserving Kale as baled silage

Young, N.E. Jones, R.[*] & Fychan, R.[*]
[*]Institute of Grassland and Environmental Research (IGER)
North Wyke, Okehampton, Devon, EX20 2 SB. UK
[*]IGER, Plas Gogerddan, Aberystwyth, Dyfed, SY23 3 EB, UK

Introduction

Kale (Brassica oleracea) was popular in the 1970's as a nutritious green fodder for animal feed. It was used on dairy farms for supplying feed at times of year when grass growth was low. The main advantages of kale are the high yields and high values for digestibility, protein and calcium content. On farms with poorly drained soils grazing the crop in the Autumn can give rise to problems due to severe poaching. This work explores the possibility of conserving kale as silage in big bales.

Materials and methods

Land which had previously been cut for grass silage had slurry applied at 28 tonnes/ha prior to ploughing and cultivating. Following an application of P_2O_5 and K_2O at 36 kg/ha the kale (c.v. Hereford) was drilled at 6.7 kg/ha on 15th June and the seedbed rolled twice. Germination was rapid and the weed population low; hence spraying for weed control was not necessary. On 14 July 50 kg N were applied as NH, NO,.

Harvesting was planned for 12 weeks after sowing, i.e. 4th September, but a prolonged period of wet weather prevented this and the crop was eventually cut on 27th September (i.e. 15 weeks after sowing) with a JF mower conditioner. Following mowing, the crop was wilted for 48 hours (though conditions were overcast and the actual loss of moisture was slight) and harvested as bales using a Welgar RP200 baler. Samples of the kale crop were taken for estimates of yield and chemical analysis. Also, botanica1 separations were made into live leaf, dead leaf and stem fractions prior to oven drying at 85°C and milling through a hammer mill (1 mm sieve) prior to analysis. The bales were either film wrapped (4 layers of Silotite) or double bagged within 1 hour of baling and stored under cover for a period of 9 weeks prior to sampling and analysis.

10 bales were ensiled in total with 5 double bagged for effluent collection and 5 were film wrapped.

All baled silages were sampled on the 8 December 1994 using a motorized corer with three cores taken from each bale and bulked as one sample. Sub samples were dried overnight at 85°C for estimation of Dry Matter (DM), crude protein (CP), fibre (MADF) and water soluble carbohydrates (WSC). Fresh samples of the silage were analyzed for pH, Ammonia-N and organic acid content. Effluent production was removed from the bagged treatments and weighed as total cumulative effluent.

Results

The mean yield of kale after 15 weeks growth was 34.14 and 4.36 tonnes/ha of fresh weight and Dry Matter respectively. The DM% of the crop at cutting and after 48 hours wilting was 13.0% and 16.2% respectively.

The mean chemical composition of the kale crop is given below. The crude protein content of the whole plant was low, probably as a result of variation in sampling, while the leaf only fraction was much higher (16.3%). Digestibility was high > 75% which reflects the low fibre content (Modified Acid Detergent Fibre). Sugar content was extremely high and would account for the excellent fermentation found in all silages. Mineral content showed a calcium content > 1 .O% however, the phosphate content is low (0.28%). Potassium is inherently high in kale > 3.0% and is one of the minerals that accumulates in the plant as a result of slurry application.

Chemical analysis of separated plant parts (live leaf, dead leaf and stem) of the kale showed considerable variation in all the parameters estimated. As expected the fibre content of the dead leaf and stem were much higher than the leaf fraction resulting in low digestibility of the stem and dead material. It is interesting to note that the calcium content of the dead leaf material was almost 10 fold higher than in stem. The WSC content of the dead leaf material was extremely low (8.4%) and would be detrimental to fermentation if present in large quantities.

Effluent production accounted for almost 6% of the total weight at ensiling. The mean difference in weight of bagged bales and film wrapped bales post-ensiling was 55 kg which would account for the 45.6 kg of effluent collected from the bagged bales. Effluent from the wrapped bales would have been lost through the joins in the film wrap and directed to a bulk effluent storage tank.

All silages were well fermented with similar pH values of less than 4.3 and ammonia-N content less than 5%. Acetic acid content was low in both treatments which suggests only slight spoilage from yeasts and moulds. Quality of silages were high in both treatments with an ME content in excess of II.7 and protein content of greater than 16%. The higher protein content of the silages compared to the standing crop analysis would suggest evidence of sample variation in standing crop probably as a result of variance in protein content between different plant parts. The dry matter content of silages were extremely low and effluent production would be a major problem if the silages would have been forage harvested and ensiled in bunker silos,

Conclusions

Consetving kale as big baled silage has attractions to dairy farmers because the crop can now be grazed, to fulfil a temporary shortage of grass, or conserved as a winter feed. The technique only requires equipment readily available to the grassland farmer and offers the opportunity of providing high yields of nutritious material which, because of the high levels of energy and protein, complement other conserved crops. The whole system of kale conservation lends itself to being harvested as baled silage since effluent production is more easily controlled and also makes mixed feeding with other crops more easily managed.

Long term effect of lime sources and rates on forage yield mineral composition and on soil chemical properties

Ana Luisa Pires,
Dep. Edafologia, UTAD, Vila Real, Portugal

Introduction

Soil acidity associated with high levels of exchangeable Al and low levels of exchangeable Ca and Mg are believed to be the predominant chemical factors limiting forage growth and animal performance in the Trás-os-Montes region of northern Portugal. The addition of lime is recognized as necessary in order to increase forage production and to permit the introduction of high quality forages such as legumes.

The objectives of this research work are to examine the effect of moderate lime rates applied seven years ago:

1 - on yield and mineral composition of rye, ryegrass and vetch and

2 - the effect of species and lime on soil chemical properties (0-60 cm depth).

Materials and methods

The experiment was conducted at Vila Real, northern Portugal. It started in October 1986, by applying dolomitic and calcitic limes, at the rates of 2.7 (Dl; Cl) and 5.4 t ha^{-1} (D2; C2), to plots (2.4 x 5.0 m) arranged in a split-plot design, with three replications. Since then, every year, green fodder crops were grown in the same plots.

Results and discussion

Seven years after lime addition, pH in the upper 20 cm of limed soil is higher than pH of control plots. Species, however, also influenced pH. In plots cropped with rye, pH is higher ($P<0.05$) than cropped with ryegrass or vetch. This effect of species may be related to their different Ca and Mg requirements and in the specific case of vetch may be also related to the fact of obtaining N mostly from symbiotic association with rhizobia. Only in plots with rye, pH is above its initial value which was of 5.0. Although the effect of lime is noticeable below the upper 20 cm of soil, only in plots with rye the effect was significant, Cl and C2 treatments, at the 40-60 cm soil layer.

The increase in pH was accompanied by a decrease in acidity, indicating that lime surface incorporation can decrease acidity not only in the upper soil layer but, if enough time is allowed, it can also prevent subsurface acidity from developing under acidifying species as legumes. In the unlimed vetch plots, exchangeable acidity was sharply increased in the top 40 cm of soil. In seven years, it increased from 1.48 (0-20 cm) and 2.39 $cmol_c$ kg“ (20-40 cm) to 2.55 (0-20 cm) and 3.50 $cmol_c$ kg-’ (20-40 cm).

All limed plots have higher ($P<0.05$) exchangeable Ca and the plots that received dolomitic lime also have higher ($P<0.05$) exchangeable Mg. When calcitic lime was added, exchangeable Mg levels were similar to those of unlimed plots. Increases in exchangeable Ca with increasing lime rate were observed until 40 cm depth, being the one obtained with C2 the highest ($P<0.05$). Increases in exchangeable Mg were noticed until 60 cm depth. Greater Mg movement than Ca was also observed by Pleysier and Juo (1981) and Messick et al., (1984).

Calcium concentrations in ryegrass and vetch increased with increasing lime rates, being the increase more accentuated in the C2 treatment. In rye, Ca concentration was not affected by liming which happened since the 1st growing season (Pires et al., 1990). Both dolomitic lime rates increased ($P<0.05$) Mg concentration.

Only the higher calcitic and dolomitic lime rates, 5.7 t ha", significantly increased ryegrass and vetch yields, being the increase more remarkable on vetch. Usually legumes respond better to liming than grasses mainly due to the influence of pH and related acidity factors on nodulation and subsequent supply of N through symbiotic fixation (Pires et al., 1992). The higher production in C2 and D2 treatments may be related with the higher reduction in acidity and the higher increase in Ca, since yields obtained with C2 and D2 treatments were not different. None of the lime treatments significantly increased rye yields. In fact, the higher lime rates had a negative effect ($P<0.05$), which was noticeable since the 1st growing season, 1986/1987 (Pires et al., 1990). This may indicate that the regional cultivar used is very well adapted to the acid soils where it was developed. According to Foy et al., (1974) and Mugwira et al., (1981), the extent to which a species may tolerate acidity is dependent not only on genetic factors but also on the soil characteristics of the regions where cultivars were selected.

Conclusions

Results from a 7-year experiment indicate that relatively low rates of surface applied calcitic and dolomitic limes, 5.7 t ha-‘, were adequate to sustain yield of ryegrass and vetch. Although calcitic lime was more effective in decreasing soil acidity and in increasing exchangeable Ca than dolomitic, the lower Mg concentrations in forages would make dolomitic a more desirable lime source, because Mg is not only important for plants but also for the animals fed with those plants.